REPORT OF THE SUPERINTENDENT

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OF THE

U. S. COAST AND GEODETIC SURVEY

SHOWING

THE PROGRESS OF THE WORK

DURING THE

FISCAL YEAR ENDING WITH

JUNE, 1882.

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Annual Report of the Superintendent of the Coast Survey

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LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING

In compliance with section 4690, Revised Statutes of the United States, a report of the Superintendent of the Coast and Geodetic Survey for the year ending June 30, 1882.

DECEMBER 20, 1882.—Referred to the Committee on Printing.

JANUARY 18, 1883.—Mr. ANTHONY, from the Committee on Printing, reported back a concurrent resolution, which was considered and agreed to.

TREASURY DEPARTMENT, *December* 16, 1882.

SIR: In compliance with section 4690, Revised Statutes of the United States, I have the honor to transmit herewith, for the information of the Senate, a report addressed to this Department by J. E. Hilgard, Superintendent of the United States Coast and Geodetic Survey, showing the progress made in that work during the fiscal year ending June 30, 1882, and accompanied by a map illustrating the general advance in the operations of the Survey.

Very respectfully,

CHAS. J. FOLGER,
Secretary.

The Honorable DAVID DAVIS,
President of the Senate.

ABSTRACT OF CONTENTS OF REPORT.

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ERRATA.

Page 173, 4th line from top, for 1860 read 1875.
Page 176, 5th line from bottom, omit first = sign.
Page 176, 4th line from bottom, for 0.89 read 0.089.
Page 183, 17th line from top, for $\pm$ read $-$.
Page 201, 7th line from bottom, for "33" read "31."
Page 202, 2d line from top, for "page 13" read "plate 31."
Page 202, 17th line from top, for "page 13" read "plate 31."
Page 204, 7th line from bottom, omit "page 22."
Page 279, 7th line from top, for "Appendix No. 13" read "Appendix No. 12."

REPORT.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, December 16, 1882.

SIR: In accordance with law, and with the regulations of the Treasury Department, I have the honor to submit herewith my report on the progress of the work of the Coast and Geodetic Survey during the fiscal year ending with June, 1882.

PART I.

It will be seen from Appendix No. 1, in which is given an abstract of the localities of work and of the various operations in the field and afloat, that while the leading aims of the Survey, the security of navigation and thereby the promotion of commerce, have been kept steadily in view, other objects of the utmost value to the proper development of the work as related to its national importance and to its scientific accuracy have not been lost sight of.

Hydrographic surveys have been prosecuted in the waters and off the coasts of fifteen States and two Territories; in the course of these surveys, dangers to navigation have been discovered and mariners warned by notices widely disseminated; topographic surveys for the exact definition and delineation of shore line have been carried on in ten States and one Territory; a special topographic survey has been in progress in the District of Columbia; the triangulations, primary, secondary, or tertiary, which precede and form the basis of the two classes of work first named, have been advanced along the coasts and within the boundaries of twenty-one States and one Territory; included in this work has been the measurement of a primary base line in California and the extension of the transcontinental triangulation along or near the thirty-ninth parallel, for connecting the survey of the Atlantic coast with that of the Pacific, and incidentally for the measurement of an arc of the parallel; observations for latitude and azimuth have been made at important stations of the primary triangulation; longitudes of important cities in the interior States have been established by exchanges of telegraphic signals; lines of leveling of precision have been carried from a point on the Atlantic sea-board towards a station on the Mississippi River; the values of the magnetic elements have been ascertained at many points previously unoccupied, and for purposes of comparison, and study of the secular change, at others before occupied; determinations of the force of gravity by pendulum experiments have been made; tidal observations at self-registering tidal stations on both the Atlantic and Pacific coasts have been recorded; the study of ocean currents has been continued and lines of deep-sea soundings run with temperature observations for the further investigation of the phenomena of the Gulf Stream.

GENERAL STATEMENT OF PROGRESS.

The synopsis which is here presented of the operations in progress in the several localities of work during the fiscal year ending June 30, 1882, as stated in detail in the report, is followed by a statement of work proposed during the fiscal year ending June 30, 1884, with estimates of the amounts needed to accomplish it.

I.—FIELD-WORK.

ATLANTIC COAST.—During the year ending with June, 1882, the work of the Survey has included the following operations upon the coasts and within the borders of the New England States: Topography and supplementary triangulation of Pleasant Bay and River, Me.; topography of the shores of Harrington River, Flat Bay, Back Bay, and adjacent islands, Me.; topography of the shores of Narraguagus River, Pigeon Hill, and Narraguagus Bays, and the neighboring islands, Me.; hydrographic survey of Goldsborough Bay and of Dyer's Bay, Me.; tidal observations with self-registering tide-gauge continued at Pulpit Cove, North Haven Island, Me.; examination of dangers in the vicinity of the harbors of Gloucester and Salem, Mass.; changes off Pollock Rip, coast of Massachusetts, and shoal in that vicinity examined for the Coast Pilot; absolute determinations of gravity by pendulum experiments at Cambridge, Mass.; occupation of stations at Mount Washington and Trask Hill for determining points in the triangulation of New Hampshire; stations occupied for the determination of points in the triangulation of Vermont; primary triangulation for the connection of Lake Champlain with the survey of the coast; observations with self-registering tide-gauge continued at Providence, R. I.; determinations of buoys and location of oyster-beds for the Shell-Fish Commissioners of the State of Connecticut, and examination of dangerous rock in the eastern entrance to Long Island Sound.

Work on the coasts and within the limits of the States of New York, New Jersey, Pennsylvania, and Delaware has included a hydrographic resurvey of part of the lower bay of New York; topography of the west shore of the Hudson River from Haverstraw northward, and determination of points by triangulation for the topographical survey; re-marking of stations of the old triangulation of the Hudson River; reconnaissance and primary triangulation across the northern part of the State of New York for connecting the triangulation of the Hudson River and Lake Champlain with that of Lake Ontario; line of geodesic leveling carried from Sandy Hook, N. J., to Hagerstown, Md.; reconnaissance and triangulation in the northern part of the State of New Jersey; topography of the coast of New Jersey continued from Hereford Inlet northward; examination of changes in Delaware and Chesapeake Bays, and verification of data for the Coast Pilot; hydrographic resurvey of Delaware Bay and River; investigation of changes in that bay and river since earlier surveys continued; continuation of the triangulation of Delaware Bay and River, and of the topography of both shores of the river; determination of the position of the new City Hall, Philadelphia; and occupation of stations for determining points in the triangulation of Pennsylvania.

Within the District of Columbia and the State of West Virginia, and upon the coasts and within the boundaries of the States of Maryland, Virginia, and North and South Carolina, the operations of the work have included a hydrographic resurvey of Chincoteague Shoals, coast of Virginia; special triangulation for the determination of points in the vicinity of Hampton Roads, Norfolk Harbor, and Elizabeth River, Va.; continuation of topographic survey, vicinity of Norfolk; hydrographic resurvey of Norfolk Harbor; determination of the magnetic declination, dip, and intensity at the station on Capitol Hill, Washington, D. C.; absolute determinations of gravity by pendulum experiments at Baltimore, Md., and Washington, D. C.; longitude of Cincinnati, Ohio, from Washington, D. C., determined by telegraphic exchanges of signals; also longitude of Charlottesville, Va., from Washington, D. C.; continuation of the detailed topographic survey of the District of Columbia; completion of the survey of the site for the new Naval Observatory in the District of Columbia; extension of the reconnaissance and primary triangulation in West Virginia westward towards the Ohio River; reconnaissance, triangulation, and hypsometric observations in the region about Washington, D. C., for the construction of a general map; determinations of the magnetic declination, dip, and intensity completed at stations in West Virginia and Virginia; latitude, longitude, and azimuth observed at those stations for magnetic purposes; lines of deep-sea soundings with serial temperatures run normal to the coast between Currituck Light House, N. C.; and Jupiter Inlet, Fla.; position of a shoal determined in the vicinity of Cape Fear, N. C.; examination of shoal reported off Georgetown Entrance, and resurvey of part of Beaufort River, S. C.; and establishment of a self-registering tide-gauge at Fort Sumter, Charleston Harbor, S. C.

Upon the east and west coasts of the State of Florida, and on the coasts and within the limits of the Gulf States, the following operations were in progress: Continuation of the survey of Indian River southward to Jupiter Inlet, Fla., and determination of points on the beach for off-shore hydrography; continuation of hydrographic survey of the east coast of Florida; hydrographic resurvey of Key West Harbor and Northwest Channel Bar, Fla.; triangulation of the west coast of Florida between Tampa Bay and Charlotte Harbor; hydrographic survey of the west coast of Florida to the northward and to the southward of Tampa Bay; hydrographic survey of the inner and outer bars of East Pass, Saint George's Sound, Fla.; completion of hydrography in vicinity of Saint Joseph's Bay and Cape San Blas, Fla.; hydrography of the bar of Pensacola Harbor, Fla.; determinations of the magnetic declination, dip, and intensity, with observations of latitude, longitude, and azimuth for magnetic purposes at stations in Alabama; triangulation, topography, and hydrography of the coast of Texas, between Galveston Bay and Sabine Pass; and triangulation, measurement of base of verification, and topography on the coast of Texas in the vicinity of Laguna Madre.

PACIFIC COAST.—On the coasts and within the boundaries of the States of California and Oregon, of Washington Territory and Alaska, field-work has included an examination of localities at San Diego and at Los Angeles, Cal., to select a site for a permanent magnetic station; continuation of reconnaissance and primary triangulation between Point Concepcion and Monterey, Cal.; topography of the coast and adjacent islands from San Luis Obispo, Cal., northward; tidal observations with self-registering tide-gauge continued at Sancelito, Cal., near the entrance to San Francisco Bay; topographical survey of ground filling gap between the surveys of Balenas and Table Mountain, Cal.; supplementary topography of San Francisco Bay and approaches, Cal.; points for this topography determined by triangulation; continuation of coast hydrography northward and westward between Bodega Bay and Point Arenas, Cal.; measurement of the Yolo primary base-line, Cal., and connection of the base with stations of the transcontinental triangulation; reconnaissance and primary triangulation extended northward from vicinity of Mendocino City towards Crescent City, Cal.; determination of the magnetic declination, dip, and intensity at stations on or near the coast between San Francisco, Cal., and Sitka, Alaska; triangulation and topography of the Columbia River, Oreg., between Saint Helen's, Portland, and Vancouver; determination of the magnetic elements at stations in Oregon and Washington Territory; topography of Port Orchard, W. T., and triangulation of Hood's Canal, Puget Sound, W. T.; hydrographic survey of bays, inlets, and ports in Puget Sound, W. T.; hydrographic reconnaissance of the waters of Southern Alaska, and tidal observations continued with self-registering tide-gauge at Saint Paul, Kadiak Island, Alaska.

INTERIOR STATES.—Work in localities between the Atlantic and Pacific coasts has included the determination of the longitude of Nashville, Tenn., by telegraphic exchanges of signals with Cincinnati, Ohio; continuation of the triangulation of the State of Kentucky; determination of stations in continuation of the triangulation of the State of Tennessee; values of the magnetic declination, dip, and intensity determined at stations in Kentucky and Tennessee with observations of latitude, longitude, and azimuth at the magnetic stations; line of geodesic levels carried from Vincennes towards Mitchell, Ind.; continuation of the primary triangulation in Illinois; reconnaissance and triangulation continued in the State of Wisconsin; determination of the values, absolute and relative, of the magnetic elements at the self-registering record station in Madison, Wis.; longitude of Saint Louis, Mo., determined by exchange of telegraphic signals with Cincinnati, Ohio; telegraphic longitude signals exchanged between Saint Louis, Mo., and Vincennes, Ind.; reconnaissance for the extension of the primary triangulation in Missouri to the westward; occupation of stations for the extension of the primary triangulation in Nevada to the eastward and continuation to the eastward of the primary triangulation in Colorado; determination of the magnetic declination, dip, and intensity at stations in Idaho; and verification of the northern boundary of Wyoming Territory.

Special investigations relative to tidal action and the tidal theory, with other mathematical and physical researches, were prosecuted in England and in Europe; determinations of the magnetic declination, dip, and intensity were made at a number of stations on the northeastern coast of America.

II.—OFFICE-WORK.

In the work of the Coast and Geodetic Survey Office the progress made has been commensurate with that of the field-work. All records of field-work pass into the office for reduction, discussion, and preparation for publication; these records may relate to reconnaissance for triangulation; to astronomical and magnetic observations; to base measurements, to the several classes of triangulation, to tidal observations, and to topographic and hydrographic surveys in the form of field sheets. In the office operations are included the drawing and engraving of charts from reduced copies of the original topographic and hydrographic maps; the electrotyping of engraved plates, the printing and issue of charts, and the maintenance of the instruments used in the Survey.

Tide-tables of the principal ports of the United States for the year 1883 have been published; the drawings of fifty-one charts have been in progress, and of this number fourteen have been finished, including eleven charts for publication by photolithography. Four copper-plate engravings of charts, and twenty-one of sketches and illustrations have been begun; one hundred and thirty-two plates of charts have received corrections; the engraving of twenty-four plates of charts has been continued; the plates of twenty-eight charts and twenty-three sketches and illustrations have been completed. An aggregate of twenty-nine thousand and forty-nine charts has been issued; in this number were included fifteen thousand seven hundred and three sent to sale-agents, and seven thousand seven hundred and eighty-three supplied for the use of the several Departments of the Government. Twelve hundred and fifty copies of the Annual Report of the Superintendent, and eight hundred and fifty-five divisions of the Atlantic Coast Pilot, including sub-divisions, have been distributed. A second edition of Division B of this work, "Boston to New York," a third edition of Sub-division 3, "Penobscot Bay and Tributaries," and the first edition of Sub-division 14, "New York to Delaware Entrance," have been published.

III.—MISCELLANEOUS SCIENTIFIC WORK.

FIGURE OF THE EARTH.

In a geodetic survey, extending over an area so large as that of the United States, the question of the size and figure of the earth becomes one of great importance. The results already reached in the regular progress of the survey, and brought out by the comparisons of astronomical and geodetic latitudes, longitudes, and azimuths are of sufficient interest to stimulate further research. These determinations give the direction of the force of gravity; on the other hand and supplementary to these, pendulum experiments will determine the intensity of this force.

With regard to the utility of pendulum work in its bearing upon the figure and density of the earth, no question can now arise. It is fully shown by the resumption of this work in recent years in the leading Government surveys conducted in India, Europe, and America. And although different opinions have hitherto been held, and are still held, as to the best and most economical modes of prosecuting gravity experiments, all geodesists agree that widely distributed pendulum stations, made strictly comparable by comparison of instruments and by adherence to uniform methods, will give results of the utmost value to geodesy and geology.

The views on this subject submitted by Assistants Charles A. Schott and C. S. Peirce at a meeting held at this office in May, 1882, for an informal conference on gravity observations, will be found stated at length in Appendix No. 22, together with the propositions formulated as the results of the conference and unanimously adopted by the participants. In another paper Assistant Peirce communicates results obtained by him for force of gravity. [Appendix No. 23.]

ASTRONOMY.

In Appendix No. 21 is given a new reduction made by the late Dr. Powalky, at the charge of the Bache Fund of the National Academy of Sciences, of the places of one hundred and fifty stars observed by La Caille at the Cape of Good Hope and at Paris between the years 1749 and 1757. These determinations by La Caille—next to Bradley the most skillful observer of his day—bear to the southern portion of the starry heavens the same relation that those of Bradley do to the northern, and form the starting-point for researches on the proper motion of the southern stars. But to make them wholly available for this purpose, a new reduction with the employment of modern constants was needed.

This Dr. Powalky, with great labor, has successfully accomplished, and has completed a new catalogue for the epochs 1750 and 1830 of the stars between the South Pole and thirty degrees south declination that were observed by La Caille repeatedly with two different instruments, a six-feet sector and a six-feet sextant. Since all of these stars have been re-observed in recent years at Melbourne, and at the Cape of Good Hope, comparisons of La Caille's places with these determinations, and with those of Dr. B. A. Gould at Cordoba, will be of great scientific value.

MEASUREMENT OF PRIMARY BASE-LINE.

An account of the successful measurement of a primary base-line in Yolo County, California, with the new compensation base apparatus is given in Appendix No. 8 by Assistant George Davidson, under whose direction the measurement was made. Upon this base-line the practical working of the new apparatus was tested for the first time. It had been constructed at the office from plans designed by Assistant C. A. Schott, and is described by him in Appendix No. 7. A discussion of the results of the measurement will appear in my next annual report.

GEODESIC LEVELING.

An investigation of the mean ocean level at Sandy Hook for the transcontinental line of geodesic leveling which starts from the Atlantic coast at that point will be found in Appendix No. 11.

This double line of levels, eleven hundred and twenty-five miles in length, passing through the States of New Jersey, Pennsylvania, Maryland, West Virginia, Ohio, Indiana, and Illinois, is marked by permanent bench-marks referred to the level of the sea at all important points on the route, and at distances apart ranging from two to forty miles. The value of these for local surveys is obvious. When this line of levels is complete from New York to San Francisco the bench-marks thus established will serve as base stations for determining heights of points in the interior along the line of transcontinental triangulation, for the relative elevations of which observations by barometer and of reciprocal zenith distances have already been made.

TERRESTRIAL MAGNETISM.

In pursuance of the plans for a systematic investigation of the distribution of terrestrial magnetism in North America, involving the determination of the magnetic elements at stations widely separated upon the northeastern coasts of the continent for comparison with observations made in similar latitudes upon the northwestern coasts, and also the determination of these elements at stations properly distributed throughout the United States for the construction of a magnetic chart, special methods of research have from time to time been organized since 1871. A collection of the results thus obtained was published as Appendix No. 9 to my last annual report. It has been deemed desirable, however, to give in detail in the present report (Appendix No. 14) the records and results of magnetic observations made at the charge of the Bache Fund of the National Academy of Sciences between 1871 and 1876, by observers trained under my direction, and supplied with instruments loaned by the Coast and Geodetic Survey Office at the request of the National Academy.

At the opening of the fiscal year 1881-'82 Lieut. S. W. Very, U. S. N., Assistant Coast and Geodetic Survey, was at Halifax, Nova Scotia, on his way to Labrador and Newfoundland, in accordance with instructions directing him to determine the magnetic declination, dip, and intensity at stations on the northeastern coast of America. Observations for these elements had been made in 1860 at Eclipse Harbor, near the northeastern extremity of the Labrador coast in connection with observations of the solar eclipse: this station was to be the northern limit of Lieutenant Very's expedition. The impossibility of obtaining transportation thither prevented the occupation of Eclipse Harbor, but by great perseverance and by the kindness of the captain of the mail steamer which makes an occasional trip to the outposts of civilization on that remote coast Lieutenant Very succeeded in reaching Nain, a Moravian settlement in Labrador, in latitude 56° 33′, longitude 61° 41′, and obtained satisfactory observations.

Three other stations were occupied on the Labrador coast; two in Newfoundland; one at Saint Pierre de Miquelon, at the entrance of the Gulf of Saint Lawrence, and seven in Nova Scotia.

The results of these observations will add much to our knowledge of the distribution of terrestrial magnetism on the North American Continent, and those made at stations previously occupied will be of value in the discussion of the secular change of the magnetic declination.

The practical importance of a knowledge of the laws governing this change is shown by the fact that four editions of Assistant Schott's paper, discussing the secular variation of the magnetic declination in the United States and at some foreign stations, have been published, and to meet the public demand a fifth one has been prepared, which appears as Appendix No. 12 of this report. In the next Appendix is given an important paper by Mr. Schott upon the distribution of the magnetic declination in the United States at the epoch 1885.0.

EXPLORATION OF THE GULF STREAM.

The facts brought out by the deep-sea soundings of Commander J. R. Bartlett, U. S. N., Assistant Coast and Geodetic Survey, carried on in the steamer Blake during the summer of 1881 across the course of the Gulf Stream, will serve to increase the interest in further investigations of the area swept by that ocean current, and of the laws which control its action. With the aid of the Siemens electrical deep-sea thermometer, the surface and bottom temperatures taken with the soundings during the cruise of the Blake will be supplemented in another season by frequent series of temperatures at various depths, and the question of the bifurcation of the Stream into warm and cold bands, over which some doubt has already been thrown, may be definitely settled.

In Appendix No. 18 will be found a report by Commander Bartlett of tests which were made by him of the actual working of this apparatus, in which the effect of changes of temperature in varying the resistance of metals to the passage of an electrical current is so ingeniously applied. A description of the apparatus with illustrations precedes Commander Bartlett's paper.

DEEP-SEA SOUNDINGS.

An account of the deep-sea soundings taken off the Atlantic coast of the United States between 1879 and 1883, in connection with the exploration of the Gulf Stream, is given in Appendix No. 19, which is accompanied by a chart showing the depth and temperatures actually observed.

STUDY OF BEND-EFFECTS IN THE LOWER MISSISSIPPI.

In connection with his duties as a member of the Mississippi River Commission, Assistant Henry Mitchell has made a study of the effects of bends in the river upon its mean depth, and upon the channel depth and mean depth of cross-section, selecting for this purpose, as presenting the least anomalies and the most permanent characteristics, a portion of the Lower Mississippi extending from the forts (about seventy-five miles below New Orleans) to Point Houmas near Donaldsonville, a total distance measured along the channel of about one hundred and fifty-one miles.

The conclusions reached by Mr. Mitchell are stated in Appendix No. 16.

INVESTIGATION OF FLUID MOTION.

The elucidation of certain problems pertaining to hydrodynamics, and more especially to the subject of the motion of vessels and of bodies such as pendulums moving totally immersed in fluid, has become desirable in relation to researches upon the tidal theory and to other questions arising in the progress of the survey, and demanding mathematical treatment of a high order.

For the study of these problems with special reference to the best method of investigating them, and for the purpose of obtaining information that would be of service in the preparation of a comprehensive treatise on fluid motion, Dr. Thomas Craig, of the Coast and Geodetic Survey, was directed to proceed to Europe, and to confer with some of the eminent physicists then in attendance upon the meeting of the British Association for the Advancement of Science, at York.

After an absence of five months in England and on the Continent, Dr. Craig returned to this country in October, having accomplished the chief objects of his journey.

TIDES OF THE PACIFIC COAST.

An elaborate discussion of the tides of the Pacific coast by Professor William Ferrel is given in Appendix No. 17. It is based upon observations recorded for a number of years past at San Diego, Cal., Astoria, Oreg., and Port Townsend, W. T., using as data the hourly co-ordinates measured from the curves of the self-registering tide-gauges at the above-named stations, and treating these by the method of harmonic analysis. Either for investigations of the tidal theory or for use in predicting the tide Professor Ferrel's results have great value.

SANDWICH ISLAND TIDES.

Tidal records from the self-registering tide-gauge, loaned by the Coast and Geodetic Survey to the Superintendent of the Survey of the Sandwich Islands, have been received to the close of the year 1881, and the series is doubtless still in progress. This series of observations was begun in June, 1877, the gauge being established at Honolulu. The results obtained from them and their comparison with the Pacific coast tides will be of great interest in the general investigation of the tides of the Pacific Ocean.

ESTIMATES.

The detailed estimates for the fiscal year ending June 30, 1884, transmitted to the Department in November last, were accompanied by the following statement:

"It will be observed that these estimates conform in the aggregate to the amount appropriated for the current fiscal year, and that they have been prepared in conformity with a requirement attached to that appropriation which provides that the pay of persons continuously employed in the field and office shall be specifically estimated for, and that the estimates for the work proposed to be done in the several localities shall be submitted in much greater detail than before. Hence the principal items of the estimates are not the same as before in form, although they are substantially the same in effect.

"In making this change of form, an earnest endeavor has been made to meet the requirements of the law, while preserving a necessary degree of pliancy in the detail of work proposed to be done, and in the expenditure therefor.

"The two principal items of the appropriation, as heretofore made, have been aggregate amounts for the survey of the Atlantic and Gulf coasts, and for the Pacific coast. They embraced the pay of all persons employed in making surveys in the field, and in the work of the office, as well as all 'party expenses,' which comprise the pay of those temporarily employed as recorders, signal men, hands, cooks, drivers, or boatmen, as the case may be; the subsistence and transportation of the parties, and all requisite materials, tents, boats, and all other necessary expenses incident to the work.

"In the new form of estimates herewith submitted, the expenditures are divided as follows:

"1. *General expenses for the survey of the coast*, being party expenses as above defined. In the 'details of estimates' given below, each locality proposed to be surveyed, or class of work to be done, is specified, and the amount to be spent upon each is estimated. It is, of course, impracticable to make such estimates with great accuracy far in advance, and some discretion must be left to the Superintendent to vary the amounts according to the character of the season, or unforeseen requirements elsewhere; but this estimate will form the project for the year's work, to be adhered to as nearly as consistent with the best interests of the service, and of course the total amount appropriated under this head will not be exceeded.

"2. *Transcontinental geodetic work.*—The estimate for the continuation of the transcontinental geodetic work, or triangulation to connect the Atlantic and Pacific coasts, conforms to the amount granted for the current year, but an amount of \$3,450 for the line of accurate leveling between the two oceans has been added to this item, and deducted from the preceding one. This line of extremely accurate levels will have reached half-way between New York and San Francisco when this appropriation goes into effect.

"3. *Aid to State surveys.*—For furnishing points in aid of State surveys, same as heretofore.

"4. *Pay in field.*—This item provides for the pay of officers regularly employed in the work in conformity with paragraph 4 of the Regulations for the Government of the Coast and Geodetic Survey adopted by the Treasury Department. The actual organization of the work is represented by the classification here given of assistants, subassistants, and aids, who constitute its normal surveying force, the development of which is the natural outgrowth of the needs of the country.

"The six assistants who receive salaries between \$3,000 and \$4,000 have been in its service for an average time of forty years; the average term of service of the nineteen assistants who receive salaries between \$2,000 and \$2,900 is thirty years; that of the twenty-one assistants whose pay is between \$1,500 and \$1,900 is twenty years; the average length of service of the subassistants and aids is ten and five years, respectively.

"5. *Pay in office.*—The estimates for this service are given in great detail as to the several branches of the office work, and require no further explanation.

"6. *Office expenses.*—For purchase of materials, instruments, books, and all other expenditures necessary for the work of the office, not otherwise provided for, as recited in the details of estimates.

"7. *Rent of offices.*—Same as heretofore.

"8. *Publication of records.*—Same as heretofore. The principal object in retaining this as a separate item is the direction that the work of publication shall be done at the Government Printing Office.

"9. *Repairs and maintenance of vessels.*—Same as heretofore.

"The total of these estimates is \$573,000, against \$573,900 appropriated for the current fiscal year.

"In addition to the above, I beg leave to submit and ask the sanction of the Department for an estimate of \$100,000 for the construction of a steamship specially adapted for surveying the coast and sounds of Alaska Territory. The considerations which have been presented in favor of this appropriation are given with the details of estimates."

ESTIMATES IN DETAIL.

SURVEY OF THE COAST.—For every expenditure requisite for and incident to the survey of the Atlantic, Gulf, and Pacific coasts of the United States, including the survey of rivers to the head of tide-water or ship-navigation, deep-sea soundings, temperature, and current observations along the coasts and throughout the Gulf Stream and Japan Stream flowing off the said coasts; tidal observations; the necessary resurveys; the preparation of the Coast Pilot; a magnetic map of North America; and a compilation of data for a general map of the United States; and including compensation, not otherwise appropriated for, of persons employed in the field-work, in conformity with the regulations for the government of the Coast and Geodetic Survey adopted by the Secretary of the Treasury:

Party expenses.—For continuing the survey of the coast of Maine eastward from Moos-a-bec, and including Machias Bay and approaches, and extension of triangulation	\$11,400 00
Examination of channels between Nantucket and Monomoy	1,500 00
Continuing resurvey of Long Island Sound	24,000 00
Completing resurvey of Delaware Bay	3,000 00

Continuing examination of changes and resurveys on the sea-coast of New Jersey	$2,100 00
Survey of estuaries of Chesapeake Bay and of Sounds in North Carolina not heretofore surveyed	2,400 00
Continuing the survey of eastern coast of Florida between Jupiter Inlet and Key Biscayne	7,500 00
Continuing survey of the western coast of Florida from San Carlos Entrance southward	3,000 00
Continuing survey northward from Anclote Keys, Florida	3,000 00
Continuing survey of the coast of Louisiana from Barataria Bay westward and from Calcasieu Pass eastward	8,000 00
To complete the survey of the coast of Texas and to make such re-examination of inlets as may be necessary	3,000 00
To make off-shore soundings along the Atlantic coast and current and temperature observations in the Gulf Stream	6,000 00
For determinations of geographical positions (longitude party)	2,500 00
To complete the triangulation connecting the survey of the coast with that of the Lakes	2,700 00
To continue the primary triangulation from Atlanta towards Mobile	3,500 00
For an exact line of levels from the Gulf to the transcontinental line of levels between the Atlantic and Pacific Oceans	3,000 00
To continue tidal observations	2,000 00
To continue magnetic observations	2,700 00
To continue gravity experiments	3,000 00
To make special hydrographic examinations for the Coast Pilot	3,000 00
For compilation of data for a general map of the United States	2,700 00
For continuing the survey of the coast of California, viz: for topography from San Diego (False Point) towards San Luis Rey, from Moro Rock to San Simeon, and from Point Piedras Blancas to Cape San Martin	10,000 00
For primary triangulation from Point Sal northward, from Table Mountain southward, and from Trinidad Head to the Oregon line	20,000 00
For hydrography off the same coast	7,000 00
For continuing the survey of the coast of Oregon, viz: Topography from Umpquah River northward, including survey of Sinslaw Entrance, Koos Bay, and off-shore hydrography and completion of the surveys of Columbia and Willamet Rivers to the head of ship navigation	10,000 00
For continuing the survey of the coast of Washington Territory, viz: Continuing the triangulation, topography, and hydrography of Fuca Strait	6,000 00
For completing survey of Puget Sound	6,000 00
For examinations and surveys of such passages, anchorages, and harbors on the coast of Alaska as may be deemed most needful	8,000 00
For tide observations on the Pacific coast	2,000 00
For magnetic observations on the Pacific coast	2,000 00
For gravity observations on the Pacific coast	1,000 00
Total for party expenses	172,000 00
Transcontinental geodetic work.—For transcontinental geodetic work, including line of leveling between the Atlantic and Pacific Oceans	33,450 00
Aid to State surveys.—For furnishing points for State surveys	16,000 00
PAY IN FIELD.—For the pay of officers continuously employed, viz:	
Pay of Superintendent	6,000 00
Pay of six assistants, at rates between $3,000 and $4,000 per annum	21,200 00
Pay of nineteen assistants, at rates between $2,000 and $2,900 per annum	43,000 00
Pay of twenty-one assistants, at rates between $1,500 and $1,900 per annum	36,000 00

Pay of nine subassistants, at rates between $1,100 and $1,400 per annum	$11,250 00
Pay of nine aids, at rates between $720 and $900 per annum	7,500 00
Total pay in field	124,950 00

PAY IN OFFICE.—For pay of persons employed in the office of the Coast and Geodetic Survey, viz:

In office of Superintendent, three persons, from $900 to $1,800 per annum	4,200 00
In office of Disbursing Agent, three persons, from $1,200 to $2,500 per annum	5,700 00
In office of Hydrographic Inspector, six persons, from $650 to $2,200 per annum	8,100 00
In office of Coast Pilot, three persons, from $700 to $1,500 per annum	3,480 00
In office of Assistant in Charge, eight persons, from $720 to $1,800 per annum	8,100 00
In Computing Division, eight persons, from $600 to $1,870 per annum	9,600 00
In Division of Tides, three persons, from $720 to $2,000 per annum	3,770 00
In Drawing Division, fifteen persons, from $400 to $2,400 per annum	19,300 00
In Engraving Division, twenty-four persons, from $600 to $2,400 per annum	37,200 00
In General Service Division, nineteen persons, from $400 to $2,000 per annum	16,350 00
In Instrument Shop, eight persons, from $500 to $2,000 per annum	9,100 00
In San Francisco sub-office, three persons, from $720 to $1,800 per annum	3,600 00
Total pay in office	128,500 00

In further explanation of the above estimate it may be stated that the amount $128,500 is required for pay of mathematicians and computers employed in the reduction and discussion of the geodetic, astronomical, and magnetic observations sent in by the assistants in the field; of draughtsmen; for the reduction of the plane-table sheets and the construction of the different classes of charts for publicatioh; of engravers, copper-plate printers and electrotypers; of computers for the discussion and prediction of tides; of persons employed in collecting, verifying, and arranging the data required for the Coast Pilots; of the hydrographic draughtsmen in the office of the Hydrographic Inspector, required for the reduction of the hydrographic surveys by the officers of the Navy attached to the survey; of the disbursing agent and accountants; of the mechanicians in the Instrument Shop for the construction and repair of instruments, including the carpentry; and of others employed in the official correspondence; writing and copying reports; preservation of the records of the Survey; distribution and sale of charts; and pay of packers, messengers, and watchmen.

OFFICE EXPENSES.—For purchase of new instruments, books, materials, &c.; photolithographing, transportation, fuel, gas, and expenses of all kinds necessary for the execution of the office work, as per the accompanying explanation:

Purchase of new instruments and books	$8,450 00
Materials required for the Drawing Division, and map-mounting; by the Instrument Shop for the construction and repair of instruments; supplies for the carpenter's shop; and for allowances to the assistants employed in charge of the office details, in accordance with the regulations	7,950 00
For chart paper, printing-ink, copper-plates, engraver's supplies, and for copper, zinc, and chemicals for electrotyping	7,590 00
For extra engraving	1,800 00
For photolithographing charts for immediate use	7,200 00
For stationery for the office and field-parties, transportation of instruments, &c., office furniture and repairs, and for office wagon	6,120 00
For fuel, gas, telegrams, extra labor, and washing	3,500 00
For miscellaneous and contingencies of all kinds, including the traveling expenses of assistants and others employed in the office sent on special duty in the service of the office	2,990 00
Total for office expenses	45,600 00

RENTS.—For rent of buildings for offices, work-rooms, and workshops in Washington.	$10,500 00
For rent of fire-proof building No. 205 New Jersey Avenue, including rooms for standard weights and measures, for the safe-keeping and preservation of the original astronomical, magnetic, hydrographic, and other records; of the original topographical and hydrographic maps and charts; of instruments, engraved plates, and other valuable articles of the Coast and Geodetic Survey	6,000 00
Total for rent	16,500 00
PUBLICATION OF RECORDS.—For continuing the publication of observations and their discussions made in the progress of the Coast and Geodetic Survey, including compensation of civilians engaged in the work, the publication to be made at the Government Printing Office	6,000 00
REPAIRS AND MAINTENANCE OF VESSELS.—For repairs and maintenance of the complement of vessels used in the Coast and Geodetic Survey	30,000 00
In all, for Coast and Geodetic Survey	573 000 00
PROPOSED STEAMSHIP FOR ALASKA.—For the construction of a steamship especially adapted for surveying the coast and sounds of Alaska Territory	100,000 00

In explanation of the preceding item the following correspondence is appended:

TREASURY DEPARTMENT, *July* 1, 1882.

SIR: I have had the honor heretofore of transmitting you a communication to me relative to an appropriation for the building of a vessel for the purposes of "the Coast Survey" along the coast of Alaska. I also, in reply to a letter from you, informed you that in my opinion there was no vessel of the Revenue Marine service that could be used for the purpose above mentioned.

I now have the further honor of handing to you another letter from Professor Hilgard, of the United States Coast and Geodetic Survey, on the same subject, and of saying that I am convinced that this effort on the part of that office is not mere pertinacity, but is made from a hearty belief in the needs of that branch of the public service and of the commercial marine interests of the country.

From conversation with gentlemen connected with that branch of the service, and from some observation of facts, I am prepared to say that the Territory of Alaska is worthy of the attention and fostering care of Congress, and that no means consistent with a wise economy should be spared to bring it within the range of commercial enterprise and open its resources to the public reach and use. Doubtless a survey and charting of the coast, straits, inlets, bays, and harbors, as perfect as may be, is an efficient means to that end, and vessels of suitable build and capacity are needful So much I am able to say unhesitatingly and of my own observation.

The specific thing sought at the present is an appropriation of $100,000 for the building of a vessel. As to the need now for this I must rely upon the statements of those having the general matter in charge; and those statements are well set forth in the accompanying letter of Professor Hilgard. They seem to me to be more than plausible as to the need of a vessel. I commend them to the attention of the committee, which is finally to judge whether the sum asked for can be afforded from the public moneys without inconvenience to other urgent demands upon the public moneys.

Very respectfully,

CHAS. J. FOLGER,
Secretary.

Hon. FRANK HISCOCK,
Chairman Committee on Appropriations, House of Representatives.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, February 3, 1882.

SIR: The rapidly growing commerce and navigation on the coast of Alaska warns us of the importance of making as early as possible more complete surveys of that coast than have hitherto been practicable with the means at the command of the Department.

A consideration of what has been done will show that great diligence has been used by this office since the acquisition of that Territory. A general map of the coast from previous Russian and British explorations and local surveys, a general chart of the coast, and an atlas of harbors in Alaska were published as early as 1869. A volume of sailing directions was compiled and published in 1869. More exact surveys of important localities have since been made by this office, and thirty-eight charts from original surveys have been published. Two of these are from surveys made by United States naval vessels on duty on that coast. A new and much enlarged edition of the Alaska Coast Pilot is in hand and over one hundred pages stereotyped, and fifteen charts illustrative of the same are engraved and nearly ready for printing. Seven additional charts of hitherto unsurveyed localities are in hand for engraving from observations by the officers of the Survey, and the number of astronomical positions fixed and magnetic observations preparing for publication is very large.

In the mean time the people on the Pacific coast are calling for a more rapid progress of the survey on the northwestern coast, as is evidenced by memorials presented to Congress, copies of which are appended to this letter.

In order to carry on the work to good advantage a new vessel especially adapted for the purpose is absolutely necessary. The required qualities of such a vessel are—size for carrying a comparatively large staff of officers and crew; capacity for a large quantity of provisions and coal, which cannot be easily replaced during a long season's work; strength to resist damages liable on a dangerous and unknown coast, water-tight compartments being a necessary adjunct; speed to overcome the strong currents of the narrow channels; economy of fuel and proper sail-power, assisting in the saving of fuel when practicable, making it possible to maintain the field for the full length of the working season, and keeping the expenses within the limits of the appropriation made by Congress.

The plans for such a vessel have been prepared under the direction of my predecessor, Capt. C. P. Patterson, and this office is ready to make contracts, if authorized by Congress.

In view of the foregoing considerations, I have the honor to request the Department to recommend to Congress a special appropriation for the construction of a vessel for these surveys, at a cost not exceeding the sum of $100,000.

It is very desirable that the appropriation, if approved, be available at an early day, in order that advantage may be taken of the surveying season of 1883.

Very respectfully,

J. E. HILGARD,
Superintendent.

The Honorable SECRETARY OF THE TREASURY,
Washington, D. C.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, June 29, 1882.

SIR: On the 3d of February I had the honor to address you a letter, asking that you would recommend to Congress an appropriation of $100,000 for the building and equipping of a vessel for the survey of the coast of Alaska.

The matter was also urged by memorials from the Chamber of Commerce of San Francisco, from the Geographical Society of the Pacific, and from the California Academy of Sciences. These memorials accompanied my letter.

These documents were transmitted by you to Congress, and no appropriation for the purpose proposed appearing in the sundry civil bill, I beg to recall the subject to your attention, because the commercial necessities of the Pacific coast particularly demand a survey of the great interior passages of Alaska, notorious for their hidden and unknown dangers; and because the Coast Survey has no vessel properly adapted and fitted for such duty. The Hassler is now there, but is especially needed for the hydrography of the coasts of California, Oregon, and Washington Territory.

Urgent applications were made upon the Superintendent last year by the Chamber of Commerce and other commercial bodies for special surveys of such dangerous passages as Wrangell Strait, whereby several hundred miles are saved on each trip of the mail and coasting vessels.

Since the date of my letter, I have also had the personal statements of officers of the Survey who have been through these waters, and who have given attentive study to the resources, requirements, and development of that country.

The resources of Alaska are much greater than are generally known; for example, the area of her cod-fishing banks is estimated to be four times greater than that of the Banks of Newfoundland, and the coasts of the Archipelago Alexander embrace between eight thousand and nine thousand miles clothed with timber of great size and excellent quality, which will be a source of supply when all other sources are exhausted.

Of the mineral wealth of the Territory the favorable reports have been confirmed.

The existing charts of this region are in a great measure founded upon those of Vancouver of 1792, and but recently the revenue cutter Corwin, when returning with the Rodgers expedition, struck upon unknown dangers.

Added to the unreliable and misleading details of these charts, the dangers to navigation are increased by the heavy seas of these high northern latitudes and the unusual amount of rainy, thick, and foggy weather, together with the short daylight of winter.

The number of vessels trading to these waters and the number of fishing and whaling vessels have yearly increased.

There are no trustworthy pilots for the interior straits of the Archipelago Alexander, for the Shumagin and Aleutian Islands, or for the approaches to the great rivers Yukon, Kriskorin, etc. The few English pilots for the regular route from Fuca Strait to Sitka demand extraordinary remuneration (as high as five hundred dollars per month for Admiral C. P. R. Rodgers).

For want of Government charts, companies trading to these waters are using private charts compiled from information obtained by their captains.

In consideration of these difficulties which beset the commercial community of the Pacific coast, the cost of insurance is unusually large and oppressive, and in winter it is practically prohibitory.

We have endeavored, with the very limited means at our disposal for Alaska, to meet some ot the most urgent wants of commerce by the examination of dangerous localities, by the publication of sailing directions, the compilation of charts, observations of tides, etc. It must be evident, nevertheless, that little systematic work can be done without a vessel constructed and equipped expressly for this duty, and whose whole time shall be devoted thereto. The Hassler, now temporarily in Alaska, is a single-shell iron vessel, not suited to these waters, as I have more explicitly detailed in my previous letter, and should she strike upon an unknown danger would doubtless be a total loss, just as the Suwanee was lost in Shadwell passage.

The practical acquaintance of the officers of the Coast Survey with the waters of Alaska; their knowledge of the resources of the Territory, and their familiarity with the commercial demands of the Pacific coast for charts to aid navigation, conspire to give force to my request for this vessel.

Very respectfully,

J. E. HILGARD,
Superintendent.

The Honorable SECRETARY OF THE TREASURY.

OBITUARY.

CARLILE P. PATTERSON, Superintendent of the Coast and Geodetic Survey, died at Brentwood, his home near Washington, D. C., on the 15th of August, 1881.

Mr. Patterson was born at Shieldsborough, in the State of Mississippi, August 24, 1816. Entering the service of the United States as a midshipman in the Navy at the age of fourteen, upon reaching the grade of passed midshipman he was ordered to duty on the Coast Survey during the superintendency of Mr. Hassler, and as lieutenant in 1846 he took charge of a hydrographic party in the Gulf of Mexico, under the direction of Superintendent Bache.

The earnestness and vigor with which the hydrographic work in Mobile Bay and Harbor was prosecuted by Lieutenant Patterson so impressed the citizens, that the corporate authorities, through the mayor of the city, addressed a communication to him in December, 1847, as "commanding the party of the Coast Survey," expressing their gratification at the attention to the interests of the city manifested by the Superintendent and the officers under his direction. While promptly acknowledging this communication in behalf of the Superintendent, Lieutenant Patterson was equally prompt in correcting an erroneous impression, and in stating that his own party was but one of several, naming the officers upon the accuracy of whose observations the value of his own results depended.

At this time, war between the United States and Mexico was in progress, and the impulse to serve his country more immediately in the line of duty in his profession was one that Lieutenant Patterson could not resist. He asked permission from the Superintendent to retire temporarily from the Survey, in order to conduct an explosive flotilla, powerful enough to disable the great fortress which defended the Gulf approaches to Vera Cruz. He knew that the enterprise might be hazardous to himself personally, but in his own view the results would be speedy and sure. His proposal the Superintendent thought it best to decline.

Upon being relieved from duty on the Survey, Mr. Patterson's preference for pursuits that would fully enlist his constitutional activities led in 1850 to his retirement from the Navy, and his taking command of a Pacific mail steamship. In this and in other private business he continued till 1861, when the needs of the country again demanded his services, and he accepted the position of Hydrographic Inspector in the Coast Survey, offered him by Superintendent Bache.

In this capacity, the demands made upon his energies were arduous, the course of public events calling for unusual efforts to meet calls from the Government for charts and information indispensable to operations afloat. The special fitness he manifested in devising plans in a time of great public emergency, and his close attention to every detail of their execution, won for Mr. Patterson the unrestricted confidence of his distinguished chief. This feeling was shared by Professor Bache's successor, who took occasion not infrequently to express his high appreciation of the labors of the hydrographic inspector, referring particularly to his faithful and comprehensive suggestions in the stimulating and developing of individual thought, and to his wise recommendations concerning commercial and maritime interests.

Upon the resignation of Professor Peirce in February, 1874, Mr. Patterson was appointed Superintendent. He brought to the performance of his duties an intimate acquaintance with the requirements of the work gained by his long training and wide experience in its service, and an earnest devotion to its interests as viewed by a man of strong will, sound judgment, and unremitting executive energy, determined to uphold a high standard of efficiency, and to spare no personal labor in behalf of the needs of the Government.

His tenure of the office marked strongly an epoch in the history of the Survey. His predecessor, Bache, held in thought the plan of a triangulation along the Blue Ridge as essential to the completion of the work, but in his day restricted views prevailed in regard to public expenditure. Other impressions succeeded in time. Nations far inferior to our own had maps of their territory. The eminent mathematician, Peirce, had expanded the scope of the work, and a geodetic survey to span the continent, and to lay the foundation of a general map of the country had charms for a mind like that of Patterson. He believed that results might be proportioned to thought previously given, and hence it was that in schemes for triangulation his patient study in advance ceased only when improvement in the plan was found to be impossible. He succeeded in carrying out the policy of his predecessor and in preserving unbroken the organization of the Survey throughout a period of great commercial depression and of close retrenchment in every Government expenditure.

His death is to be deplored as that of one who was great in spirit, gentle in his dealings, forbearing towards subordinates, magnanimous in the presence of equals, and himself the peer of any in exalted character. All elements of truthfulness, the height of manly courage, the most tender susceptibilities of human sympathy, were his in large measure.*

OBITUARY.

THOMAS McDONNELL died at Washington, D. C., May 29, 1882, in the seventy-ninth year of his age.

Mr. McDonnell's connection with the Coast Survey began in 1833, under the superintendency of Mr. Hassler. He entered its service as artificer in the party of the Superintendent, acting also in the capacities of paymaster and quartermaster. The unvarying fidelity and good judgment with which he discharged these duties commended him to the respect and confidence of his official superiors and won for him their friendship and esteem. For thirty-three years he served actively in the field, and was then placed in charge of the map and chart room of the office, a position which he held till his death.

Having served under five successive Superintendents, and for a period of almost fifty years, Mr. McDonnell's memory, which retained its powers unimpaired to the last, was well stored with recollections of persons and events of earlier days, and he was consulted in regard to them almost as an oracle.

Few of his cotemporaries on the Survey now survive him. His friends, while deeply lamenting his loss, are partly consoled for it by the reflection that he was spared to them long enough to reap the rewards which attend upon honorable old age.

[* A memorial of Mr. Patterson will be found in Appendix No. 24.]

PART II.

In the detailed recitals of field-work which follow, under the several heads of sections, are stated the localities in which work has been in progress, the names of the officers conducting it, and the kind of work executed, with brief notices of the results attained, following the same geographical order as that observed in Appendix No. 1.

The report of the Assistant in charge of office and topography follows. In this is given a summary of the operations of the office during the fiscal year, with references to the appendix containing the detailed reports of the several office divisions. These papers will be found in Part III of this report, which includes, in addition to them, other appendices of a scientific character, wherein are discussed certain methods and results of the Survey. References to some of the more important of these appendices have already been made in Part I.

As my immediate adviser in matters pertaining to the details of the hydrographic branch of the service, and as Chief of the Hydrographic Division in the office, Commander C. M. Chester, U. S. N., Assistant Coast and Geodetic Survey, remained on duty during the year. His report (Appendix No. 6) gives a list of naval officers on Coast-Survey duty; the number and names of the vessels belonging to the Survey, their commanders, and localities where occupied at the beginning of the fiscal year, and a summary of the work done by the hydrographic draughtsmen under his direction in the office.

Commander Chester refers to the large number of charts corrected during the year, nearly four hundred, and calls attention to the hearty interest shown by the inspectors of the Light-House Board in keeping the office supplied with the latest information on the subject of aids to navigation.

Changes in the system of buoyage on some parts of the coast made necessary a large share of the corrections to charts, and involved much labor on the part of the assistant hydrographic inspector, Lieut. Richardson Clover, U. S. N., who succeeded Lieut. C. T. Hutchins, U. S. N., upon his detachment in July, 1881. The intelligent and zealous efforts of Lieutenant Clover were successfully directed towards keeping the chart-room editions as closely up to date as practicable.

SECTION I.

MAINE, NEW HAMPSHIRE, VERMONT, MASSACHUSETTS, AND RHODE ISLAND, INCLUDING COAST AND SEA-PORTS, BAYS, AND RIVERS. (SKETCH No. 3.)

Topography of Pleasant Bay and River, Me.—The topographical survey of the shores of Pleasant Bay and River, coast of Maine, was assigned to Assistant C. H. Boyd in June, 1881. He reached the field early in July, and finding that many of the stations of the triangulation of 1861 could not be recovered, made a supplementary triangulation to determine the points needed in plane-table work. The topography was begun on the 23d of July, and prosecuted until the end of October, when the field-work closed. Mr. Boyd reports the season as an unfavorable one, there being an exceptional amount of fog and rain. His plane-table sheet extends from Cape Split, at the western entrance of Moos-a-bec Reach, Maine, to Addison's Point on Pleasant River, including the shores of Cape Split Harbor, and the islands at the entrance to Pleasant Bay.

Mr. B. Bradbury, jr., served as Aid in the party during a portion of the season.

The statistics of the work are as follows:

Shore line surveyed, miles	40
Roads, miles	25
Area of topography, square miles	21
Stations occupied in triangulation	6
Positions determined	14

The work of Assistant Boyd during the winter season on the eastern coast of Florida will be referred to under the head of Section VI.

Topography of Harrington River, Flat Bay, Back Bay, and adjacent islands, Me.—Assistant W. H. Dennis took the field on the 11th of July, and after determining a sufficient number of points for use in his plane-table work, began a topographical survey of the islands and ledges to the southward of Harrington River entrance, and extended the work to include the shores of Back Bay, Flat Bay, part of Ripley's Neck, and part of the western shore of Harrington River. The season was not a favorable one, rain and fog delaying progress during twenty-six days out of ninety six. Field work closed on the 5th of November. The statistics are:

Shore line surveyed, miles	93
Roads, miles	15
Area of topography, square miles	19

Mr. E. L. Taney rendered acceptable service as Aid in the party. Assistant Dennis was assigned to duty at the office during the winter.

Topography of Narraguagus River, Pigeon Hill and Narraguagus Bays.—Assistant Charles Hosmer took up topographical work in the vicinity of Millbridge, Me., on the 14th of July, and continued it till the 17th of October, when the survey assigned to him was completed. The two topographic sheets which he executed include Boisbubert Island, forming the eastern shore of the southern part of Pigeon Hill Bay; Pond Island, and Trafton Island in Narraguagus Bay; part of the township of Millbridge forming the western shore of the Bay, and both shores of Narraguagus River from its mouth to the town of Millbridge. The work was much delayed by fog and rain. Statistics are as follows:

Shore line surveyed, miles	49
Roads, miles	27
Area of topography, square miles	21

During the winter Assistant Hosmer was assigned to duty at the office. From this he was detached temporarily, in February, for field service which will be noticed under the head of Section II.

Topography of the Narraguagus River.—The topographical survey of the shores of the Narraguagus River from Millbridge to Cherryfield was assigned to Assistant A. W. Longfellow. Field-work was begun on the 11th of July, and continued until November 14. Rain, fog, and wind were unusually prevalent during the season. Mr. Longfellow's topographical sheet joins that of Assistant Hosmer on the south, and was extended to join that of Assistant Dennis on the east. He reports the following statistics of work upon the completed sheet:

Shore line surveyed, miles	31
Streams traced, miles	30
Roads, miles	50
Area of topography, square miles	19

Hydrographic survey of Dyer's Bay and of Gouldsborough Bay; soundings in Skilling's River, Me.—At the beginning of the fiscal year, July 1, Lieut. H. G. O. Colby, U. S. N., Assistant in the Coast and Geodetic Survey, was engaged with his party in the schooner Eagre in hydrographic work upon the coast of Maine. Having completed the surveys of Rockland Harbor, and Muscle Ridge Channel, as mentioned in my last annual report, Lieutenant Colby finished in one day the running of the additional lines of soundings required in Skilling's River. These lines were run at high water over flats that are bare at low water, the tides being reduced from a level found by comparison with the bench-mark at Salisbury Cove, Maine. Soundings were also taken around all wharves in the vicinity as near high water as possible.

On the 7th of July the survey of Gouldsborough Bay was begun. All ledges were carefully examined; flats or places bare at low water were sounded as near the times of high water as practicable. The work in Joy's Bay and in West Bay or Gouldsborough Harbor was also done in this way. Lieutenant Colby remarks in his report that there is a small boat channel through Joy's Bay to Steuben at low water, and also one to Gouldsborough through West Bay. The principal anchorage for vessels of medium size is just below Garden Point, where there is plenty of water and good holding ground, but vessels must lie inside of the channel clear of the tide. Large v ssels would do well to anchor on the eastern edge of the channel below Rodgers Point.

The tide-gauge was set up below Garden Point; tides were observed through one lunar month, and a bench-mark was established.

Some additional soundings being necessary off Schoodic Head, on the eastern side of the entrance to Frenchman's Bay, to complete the chart of that bay, this work was taken up August 10 and finished August 15. The tidal observations were made at Prospect Harbor, and afterwards referred to the bench-mark at Gouldsborough Bay.

Lieutenant Colby then began, August 18, a hydrographic survey of Dyer's Bay, and completed it October 1, with the exception of some work at high water on the western shore of Petit Manan Point. For this the sea was not smooth enough at any time during the season to obtain accurate results. All ledges and flats bare at low water were carefully sounded as near high water as possible.

Examination of dangers to navigation in the vicinity of the harbors of Gloucester and Salem, Mass.—Under instructions received early in October, 1881, Lieutenant Colby proceeded with his party in the schooner Eagre to Gloucester Harbor, Mass., and made a careful hydrographic examination of Dog Bar, Round Rock Shoal, and Webber's Rock. He then examined certain dangers to navigation reported by Mr. G. T. Dexter of Boston as existing in Salem Harbor, and found in some cases less water than laid down upon the charts. Having completed this work, Lieutenant Colby closed operations for the season.

Examination of dangers to navigation at the entrances of Kennebec River and Booth Bay, Me., and in Muscle Ridge Channel and Rockland Harbor.—At the opening of the season in 1882, Lieutenant Colby was instructed to make certain hydrographic examinations upon the coast of Maine. He reached Fort Popham, at the entrance of the Kennebec River, on the 26th of May, and at once began a search for a rock reported to be in the channel to the northward of Pond Island Light. This rock was found, its position established, and the least water upon it ascertained to be 18.1 feet at mean low water. Search was also made, but without success, for a reported 12-foot spot on Stage Island Ground, on the east side of Kennebec River entrance. A bench-mark was established at Fort Popham, and observations of tides were made during two weeks.

A shoal spot with but 12 feet of water having been reported to the westward of Damiscove Island, off Booth Bay entrance, it was found after due search, established in position, and the least depth at mean low water determined to be 11.3 feet. A spot was also found to the westward of Damiscove Island called by the fishermen Damiscove Rock; it was located, but not developed, as the shoalest spot found had 31.1 feet at mean low water, with plenty of water all around it.

A 10-foot spot, reported between Squirrel and Fisherman's Islands, Booth Bay, was searched for at low water. The bottom could be distinctly seen, and the least depth found was 15.4 feet.

Heron Ledge was next visited and a careful search made for the shoalest spot, upon which 5.2 feet of water were found.

Observations for tides were taken at Booth Bay, where a bench-mark was established, and at Squirrel Island.

A careful examination was made to determine the existence or non-existence of a rock marked on the chart of Saint George's River and Muscle Ridge Channel as "Northwest Ledge," and referred to in the Atlantic Local Coast Pilot, subdivision 3 (third edition), page 253. This rock could not be found.

At the close of the fiscal year the party under the direction of Lieutenant Colby was engaged in Rockland Harbor, Me., in searching for several reported dangers. Additional lines of soundings were run for this purpose and for the verification of former work.

The following named officers were attached to the party during the season ending in November, 1881: Lieutenant H. T. Monahon, U. S. N., Master W. H. Nostrand, U. S. N., and Ensign O. G. Dodge, U. S. N.; and during the season beginning in May, 1882, Ensigns David Daniels, U. S. N., H. T. Mayo, U. S. N., and O. G. Dodge, U. S. N. The statistics here given are for the work of the season beginning May 4 and ending November 1, 1881:

Miles run in sounding	630
Angles measured	4, 178
Number of soundings	45, 562

Tidal observations.—The self-registering tide-gauge at the station in Pulpit Cove on North Haven Island, Penobscot Bay, Me., has maintained a continuous record during the year by the care of Mr. J. G. Spaulding, the observer who has had charge of it since its establishment in January, 1870.

The series of records has been almost perfect thus far, very few interruptions having occurred from ice, even in the coldest winters, owing to the effectiveness of the heating apparatus. When a short stoppage for repairs becomes necessary, hourly readings are taken upon a staff gauge. The location of this tide station, lying within twenty-five miles of deep water, and sheltered from the immediate effect of severe storms, fulfills the conditions most favorable for showing the characteristics of the tides of the Gulf of Maine. A full series of meteorological observations has been kept up since the beginning of the tidal record.

Examination for the Coast Pilot of changes in sailing lines, and of reported shoal at the eastern entrance of Nantucket Sound.—Near the close of the fiscal year, 1881–'82, it was decided by the Light-House Board to change the position of the light-vessel off Pollock Rip, on account of changes in the shoals in Monomoy Passage, and as this would involve alterations of considerable magnitude in the sailing-lines as laid down on the charts and in the Atlantic Coast Pilot, Assistant J. S. Bradford was instructed to make such hydrographic examinations of the proposed sailing-lines in the vicinity as were needful, and also to verify the reported formation of an eighteen-foot shoal close to the position of the light vessel as then existing before removal. Assistant Bradford, having performed this duty, returned to the office, and resumed his work upon the Coast Pilot. Earlier in the year he had made examinations of channels in New York entrance, and in Delaware and Chesapeake Bays; these are referred to under the heads of Sections II and III.

Measurement of the force of gravity.—Absolute determinations of gravity were made during the year by Assistant Charles S. Peirce at Cambridge, Mass., at Baltimore, Md., and at Washington, D. C. An additional statement in regard to these determinations will be found under the head of Section III. In Appendix No. 23 Assistant Peirce presents in a concise form results obtained by him for force of gravity.

Geodetic operations in New Hampshire.—In continuation of the triangulation of the State of New Hampshire, Prof. E. T. Quimby, Acting Assistant, took the field at the beginning of the fiscal year, establishing his party upon Mount Washington. At this station measurements of horizontal and vertical angles were made until the close of September. The season at this station was remarkable for an almost uninterrupted continuance of rain and fog, with severe thunder storms, during one of which the vertical circle, which was protected by a thin rubber covering, was struck by lightning. It was not seriously damaged, however, the most marked effect of the electricity being to cover the instrument with melted rubber, completely blackening it.

Trask Hill, in Wolfeborough, Carroll County, was next occupied, observations being begun October 12. At this station the weather was quite favorable, and early in November, the observations having been completed, field-work was closed for the season. Professor Quimby reports the following statistics:

Vertical angles, whole number measured	27
Horizontal angles, whole number measured	43
Vertical circle, whole number of pointings	376
Horizontal circle, whole number of pointings	2070

Geodetic operations in Vermont.—For the continuation of the triangulation of the State of Vermont, Prof. V. G. Barbour, Acting Assistant, took the field at the beginning of the fiscal year, and after establishing a station, "Chesterfield," in the town of Chesterfield, N. H., for connection with points in the scheme of triangulation of the southeastern part of Vermont, he established his observing camp on Styles Peak on the 16th of July, 1881.

The observations at this station were completed on the 11th of August, and on the 13th of August the occupation of Glebe Mountain was begun. This mountain is broad and heavily timbered, and lines of considerable length had to be cut to open views of connecting stations. Much hazy and smoky weather delayed progress. Work at this station was finished on the 21st of September, and on the 23d of the month the party was moved to White's Hill. The weather being now very favorable, the observations were completed October 6, and field operations closed for the season. Professor Barbour reports as the statistics of the work:

Horizontal angles, whole number measured	717
Vertical angles, whole number measured	432

Primary triangulation for the connection of Lake Champlain with the survey of the coast.—At the opening of the fiscal year, July 1, 1881, Assistant Richard D. Cutts was occupying a station on Bigelow Mountain, near Keeseville, Essex County, New York, for the purpose of continuing the primary triangulation to the Canada line in order to complete the connection of the survey of Lake Champlain with that of the coast.

Heliotropers had been established at two stations in Vermont, Bellevue and Highgate, distant respectively from Bigelow 30.5 and 39.6 miles, and a tripod signal erected on Dannemora Mountain, Clinton County, New York, the position of which had been approximately determined by reconnaissance. This station, the last northern one in New York, is an important point, as it was necessary that it should command Montreal and other points in Canada, the Green Mountains in Vermont, and the northern Adirondack region.

The weather having been favorable for observing, the work at Bigelow Station was finished by July 3, and on the 5th preparations were made for moving the camp to Dannemora Mountain. On the same day, accompanied by an Aid, Assistant Cutts started for Canada for the purpose of selecting the best available stations beyond the boundary line, with a view to a connection with the Saint Lawrence River, and the extension of the arc of the meridian to Montreal. Reaching Montreal on the 6th instant, a careful examination was made of the mountain north and adjoining the city, known as Mount Royal, and the summit of the easterly knob was selected. At this point the professor of meteorology at McGill College had erected a stout pole, securely braced, and finding that this could be utilized for the support of the heliotrope, an additional platform was added for that instrument, with the cordial assent f the president and professor of meteorology of that institution. The height thus obtained being sufficiently great to overlook the surrounding trees, Assistant Cutts found it unnecessary to avail himself of the permission kindly given by the mayor of Montreal and the commissioners of the park to cut down or trim such trees as might interfere with lines of sight.

After the heliotrope had been placed in position, and actually observed upon from Dannemora, the center of the axis of the instrument was transferred to a copper bolt sunk in the rock, which was reached about one and a half feet below the surface of the ground. Having erected a large tripod signal on Mount Johnston, or Saint Gregoire, in the Province of Quebec, a solitary hill rising abruptly from the plain to a height of eight hundred and forty-nine feet above tide, Assistant Cutts returned to Dannemora Station, and began observations on July 13. Heliotropes were found necessary on Mount Royal, Canada, and at Highgate and Bellevue, Vt.

The work at Dannemora was completed July 31, and the party and equipage were then transferred to Bellevue Station, near St. Albans, Vt. Heliotropes were established on Mount Royal, and on Bigelow and Dannemora Mountains. Observations were begun August 8, and the station was completed August 31. The next station occupied was Highgate, Vt. Heliotropers were found necessary at Bigelow and Dannemora Stations, New York. Work at Highgate Station was finished September 22, and field operations were then closed for the season, four stations having been occupied and completed, and the connection made between Montreal and Fire Island Base through nearly five degrees of latitude.

One station of the series, Mount Mansfield, is yet to be occupied, and also Montreal, should it be deemed necessary to measure the angles at that station. The following statistics of the season's work are presented:

Stations occupied	4
New stations, with tripod signals	6
Stations observed upon	21
Horizontal directions observed	762
Double zenith distances observed	87

Returning to Washington in October, General Cutts was assigned to duty as Assistant in charge of the office.

Tidal observations.—Records from the self-registering tide-gauge loaned in 1872 to the engineers of the city of Providence, R. I., have been submitted to the Coast and Geodetic Survey Office from the beginning of the series up to January, 1878. Good results have been obtained from these observations, and yet more valuable ones are anticipated when the complete series becomes available for discussion.

SECTION II.

CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE, INCLUDING COAST, BAYS, AND RIVERS. (SKETCHES NOS. 3 AND 4.)

Special hydrography.—In compliance with a request from the Commissioners of Shell Fisheries of the State of Connecticut for the detail of an officer to co-operate with them in locating buoys defining the limits of oyster-beds, and in other work bearing upon the oyster interests, Assistant Gershom Bradford was instructed to proceed to New Haven with his party in the schooner Palinurus soon after the beginning of the fiscal year. Upon his arrival, July 28, and after consultation with the Commissioners, Mr. Bradford found that the work immediately needed was the determination in position of a number of buoys off New Haven and Milford, marking the corners of lots used for oyster-planting, which had been occupied previous to the organization of the Commission in June, 1881. From the mouth of New Haven Harbor these lots extended about two miles off shore, and from Southwest Ledge light-house about two miles to the eastward and three miles to the westward; also three miles off Pond Point between New Haven and Milford, Conn. The pecuniary value of these oyster-grounds being already large, and steadily on the increase, it was desirable that their limits should be marked with great precision. For shore-stations permanent objects, such as houses, beacons, light-houses, etc., were in all cases selected, and their positions were referred by triangulation to points already known, the buoys being then located by the three-point problem. Soundings were taken at each buoy, and specimens of the bottom secured when needful. The work was plotted upon a scale of 1–20,000. During its progress determinations were made of the positions of Branford beacon, and of the new light-house at Stratford Point.

Assistant Bradford's report is accompanied by a copy of a map published by the Commissioners of Shell Fisheries to illustrate their report to the legislature of Connecticut, January, 1882. In this report and in the letters of Mr. J. P. Bogart, engineer to the Commissioners, ample acknowledgment is made of the value of Mr. Bradford's work. One extract will suffice: "The aid thus rendered to the Commission is opportune, giving us a successful start in our work. The vigorous showing which the Commission is able to make, is in great measure due to the assistance derived from the Coast and Geodetic Survey."

The season, beginning August 10, lasted till November 26, not including in that time an interval of nearly three weeks in October which was occupied in other duty. Following are the statistics of field-work:

Shore stations determined, number of	15
Buoys determined, number of	138
Soundings, number of	138
Specimens of bottom secured	106
Angles measured at shore stations	340
Angles measured at buoys	504

After the close of operations afloat, and until the end of March, 1882, Assistant Bradford was engaged in office-work. Early in April he was instructed to resume his labors in co-operation with the Commissioners of Shell Fisheries, and taking charge of the schooner Palinurus proceeded in her with his party to New Haven, Conn. The location of oyster-lots assigned to individuals upon new ground designated by the Commissioners, and extending well off shore from the Connecticut River westward to Stratford Point, was the work first required, and as a preliminary to this it became necessary to locate shore stations by triangulation. For points in the vicinity of Bridgeport, including Bridgeport light-house, Stratford Shoal light-house, and Penfield Reef light-house, the base used was Black Rock light-house–Stratford Point light-house. Shore-points were also established by triangulation between Southwest Ledge light-house and Falkner's Island light-house. In June the establishment of buoys at the corners of oyster-lots was begun, and was in progress at the close of the fiscal year. For this work the party had the use of a steamer furnished by the Commission. Two surveyors in their employ were detailed for several days for instruction in setting buoys. The method of setting them was substantially as follows: On application of persons owning contiguous lots, a day was set apart for them, and they were required to be ready with buoys and sinkers. The engineer of the Commission having plotted upon the Coast Survey projection the lots to be surveyed, the angles for the corners were carefully taken from the projection with a protractor of the best make. On arriving at the ground the vessel (steamer or boat) was placed upon the required spot by angles with the sextant upon shore stations and the sinker dropped with buoy attached. The buoys are slender spars of rough or sawed lumber, proportioned in length to the depth. They are usually suitably marked, and are not of sufficient bulk to obstruct navigation. Ranges for position were taken by the party and by the owners themselves, so that the latter may replace them at least approximately in case of removal by accident or wear and tear.

From the beginning of work in May to the close of the fiscal year the statistics of the work are as follows:

Triangulation stations, number occupied	17
Triangulation stations, number determined	13
Angles measured, number of	85
Buoys set, number of	196
Angles measured at buoys	428

As already mentioned, Mr. Bradford's work with the Fisheries Commissioners was for a time interrupted in October, 1881. He was instructed to locate and develop a rocky shoal off Shagwong Point, near the eastern end of Long Island. This shoal was found to be a dangerous obstruction to navigation, several fishing steamers having already struck upon it. Owing to strong tidal currents which sweep over the shoal and to the heavy surf at Shagwong Point, making it difficult to land with a boat, the work was attended with some delays, but on the 22d October it was completed. Mr. Bradford found but seven and a half feet at mean low water upon one of the rocky points, and recommends in his report the placing of a danger-buoy on the southern edge of the shoal.

With reference to the growth and culture of the oyster in the Long Island Sound beds which came under Mr. Bradford's immediate notice, he remarks upon the great dissimilarity of conditions governing their development from those which obtain in Chesapeake Bay. The Chesapeake Bay beds are mostly natural; those off the shores of Connecticut are planted. The Chesapeake oyster is subject to the attacks of different and probably less destructive enemies, while in the Sound the enemies of the oyster, notably the star-fish, would in time exterminate it were not the beds carefully watched. The natural beds in the Sound are worked almost entirely to furnish seed for planting. Many of the most intelligent oystermen advocate a "close time" on the natural beds, not during the spawning season, as in the Chesapeake, but just after that season is ended. And while it is thought that the Chesapeake oyster seldom recovers from "sanding," Mr. Bradford was repeatedly informed that on the Bridgeport natural beds the oysters are covered with sand in the storms of autumn and winter and work their way out in the spring.

Hydrographic resurvey of part of the entrance to New York Bay.—Under instructions dated July

8, 1881, Lieutenant-Commander E. B. Thomas, U. S. N., Assistant Coast and Geodetic Survey, in command of the steamer Bache, proceeded with his party in that vessel to make a resurvey of that portion of the entrance to New York Bay lying between Sandy Hook and Coney Island, including also an area of the lower Bay from a depth of four fathoms at low water outside to the eastern edge of the main ship channel, leading from Coney Island to the Narrows.

Having established a box tide-gauge on the wharf at Locust Grove, Gravesend Bay, for day observations for comparison with the standard self-registering gauge at Sandy Hook and for use of its readings in temporary reductions of the soundings to check each day's work, Lieutenant-Commander Thomas determined the position of a sufficient number of objects for use as signals and began to run lines of soundings one hundred meters apart, crossing them by other lines at the same distance apart at right angles. Where a closer development of depths was required, as upon the edges of channels, special lines were run.

With the aid of a steam launch loaned by the Navy Department, the survey was vigorously prosecuted to completion, and on October 24 the Bache returned to New York. Three hydrographic sheets embody the results of the work, two of New York Entrance on scales of 1–20,000 and 1–10,000 and one of Rockaway Inlet on a scale of 1–5,000. Lieutenant-Commander Thomas had the aid of the following named officers: Lieut. J. A. H. Nickels, U. S. N.; Master J. C. Fremont, jr., U. S. N.; Master C. J. Badger, U. S. N.; Master F. A. Wilner, U. S. N.; Master H. F. Reich, U. S. N.; Ensign E. M. Katz, U. S. N. The statistics of work are:

Miles run in sounding	1,215
Angles measured	12,542
Number of soundings	46,211

Subsequent hydrographic work executed by the party of Lieutenant-Commander Thomas in the vicinity of Norfolk, Va., and off the east coast of Florida will be referred to under the heads of Sections III and VI.

Examination for the Coast Pilot of the buoys in the channels of New York Entrance.—In April, 1882, Assistant J. S. Bradford was directed to proceed to New York and examine the buoys in the Main, Gedney, South, Swash, and East Channels in the lower Bay, with a view to the verification of their positions for the use of the Coast Pilot. Having performed this duty and made due report of the result of this examination, Mr. Bradford resumed the work of preparing for publication the third volume of the Atlantic Coast Pilot.

Tidal observations.—The self-registering tide-gauge at Sandy Hook, established in 1875 upon the wharf of the New Jersey Southern Railroad Company, has been kept in successful operation during the year by Mr. J. W. Banford. Some tides are unavoidably lost during very severe winters. A scale of one-tenth has been adopted for this gauge, so as to obtain a record of extreme high and low waters.

Determination of the position of light-ships at the entrance to New York Bay.—By instructions dated February 17, 1882, Assistant Charles Hosmer was directed to proceed to Sandy Hook, and, with the aid of Subassistant D. B. Wainwright, determine the position of the two light-ships and the whistling buoy near the entrance to the Bay of New York. This duty was satisfactorily performed, and on February 28 Assistant Hosmer reported the return of himself and assistant to office duty.

Topography and supplementary triangulation of the shores of the Hudson River.—Early in July, 1881, Assistant H. L. Whiting took the field for the continuation of the resurvey of the shores of the Hudson River. His work began with the determination of a series of points by triangulation, interpolated with points of the old triangulation, and extending along the western shore of the river from High Tor near the town of Haverstraw to the mountains back of West Point. These points, with those determined in 1880, cover the ground and range of the Highlands of the Hudson, including some of the highest peaks, such as Dunderberg, Bear Mountain, Crow's Nest, and Storm King, and complete the triangulation needed on the west side of the river between the limits named. Assistant Whiting makes special mention in his report of the services rendered by Mr. Van Orden, Aid in his party, in whose charge the details of the triangulation were placed, and by whom it was executed with accuracy, economy, and despatch.

A topographical re-survey of the town of Haverstraw being demanded, and the changes in its vicinity caused by the excavation of a large number of clay pits for the use of the extensive brick manufactories making it desirable to overlap the former work, Mr. Whiting took up the topography from the limits of his work of 1864, between Waldberg Landing and Haverstraw, and extended it northward on the west side of the river to and including the shore settlement and landing of Tompkins Cove. Mr. Whiting remarks that there is less character in the natural topography in this part of the survey than perhaps that of any locality of similar extent within the range of the Highlands, and that the artificial details, while seemingly of minor importance, were yet of such a kind as to prevent any system of generalization, and required tedious and perplexing labor in their determination and representation. Mr. Whiting had the aid of Subassistant W. I. Vinal during the season in topographical work until his detachment November 17. The completion of an unfinished topographical sheet of the previous season in the vicinity of West Point had been assigned to Mr. Van Orden about the middle of October. He filled in the spaces back of West Point, and continued the topography northward along the slope of the Crow's Nest until November 23. At this date field operations were closed for the season.

The statistics of the work, including the details of topography upon the two sheets forwarded to the office by Assistant Whiting, are as follows:

Stations occupied	16
Points determined	46
Miles of shore line of river surveyed	11
Miles of shore line of creeks	28
Miles of shore line of ponds	8
Miles of roads (main and secondary)	75
Miles of outline of clay pits	10
Area of topography, square miles	10

In accordance with the provisions of an arrangement made with the governor of Massachusetts, and sanctioned by the Secretary of the Treasury, Mr. Whiting takes service during a part of each year as a member of the Board of Harbor and Land Commissioners of the State of Massachusetts. He was occupied in the duties pertaining to this special assignment from December 1 till the close of the fiscal year.

Special operations.—In view of the continuation of the topographical resurvey of the shores of the Hudson, it was deemed desirable to recover and re-mark as many of the stations of the former triangulation as practicable. Assistant F. H. Gerdes was assigned to this duty at the opening of the fiscal year, and visited the following named stations: Prospect Hill (1), north of Newburgh, and thence proceeding northward on the western shore of the river, Bingham, Golden Ridge, Deyo, Woolley, Stewart, Adams, Prospect Hill (2), and Terry; and on the eastern shore, beginning at South Beacon and proceeding northward, Bald Hill, Underhill, Vervatin, Dennis, Lloyd, and Travers. Entire changes of topographical features accounted in not a few cases for the difficulty of recovering old station-marks, some of the hills upon which the points had been established having been cut down or covered by buildings since 1862. Of the stations just enumerated, the following could not be found: Bingham, Golden Ridge, Deyo, Woolley, Adams, on the western side of the river, and on the eastern side, Bald Hill, Underhill, Dennis, and Travers. At stations Prospect Hill (1), Stewart, Prospect Hill (2), and Terry the stone cones originally put down as station marks were found in good order. Reference marks were established wherever necessary, and at Prospect (1) and Terry granite monuments were erected. The cones at stations Lloyd and Vervatin were recovered in good order; and at station Vervatin a granite monument was placed. For stations Bald Hill, Woolley, and Dennis, which were not found, South Beacon, Stewart, and Lloyd can be readily substituted. Assistant Gerdes closed his work towards the end of October.

Primary triangulation for the connection of Lake Champlain with the survey of the coast.—As already stated under the head of Section I, Assistant Richard D. Cutts, at the opening of the fiscal year, was about completing the occupation of Bigelow Station, Essex County, New York, one of the stations in the scheme of triangulation for the connection of the survey of Lake Champlain with that of the Atlantic coast. The erection of tripod signals at the new points selected previous to the occupation of "Bigelow," and the opening of lines of sight, though attended by many difficulties arising from the unusual height, steepness, and inaccessibility of the mountain summits, had been satisfactorily accomplished by Prof. V. G. Barbour, of the University of Vermont, Acting Assistant. In the erection of signals, posting of heliotropers, and in other routine duties, Assistant Cutts acknowledges the able assistance rendered by Messrs. McNicol, Weston, and Barber, students from the scientific schools of Dartmouth, N. H., and of the University of Vermont. Mr. J. A. McNicol served as foreman, and observed the vertical angles.

Early in July the party was transferred to Dannemora Station, Clinton County, New York. The details of the occupation of this station, and the subsequent movements of the party, with the statistics of field-work, have already been given under the head of Section I.

Reconnaissance and primary triangulation across the northern part of the State of New York.— In continuation of the primary triangulation across the State of New York for the connection of the survey of Lake Champlain with that of Lake Ontario, Assistant C. O. Boutelle, at the opening of the fiscal year, was occupying Otsego Station, near Cherry Valley, Otsego County, New York. Starting from the base line, Prospect–Helderberg, which had been determined by Assistant Cutts, the scheme of triangulation as developed by the reconnaissance of previous seasons had failed to make a thoroughly satisfactory connection with the high peaks of the southern Adirondacks. It was not till the latter part of July that a clear, sharply defined horizon gave Mr. Boutelle the opportunity he desired, enabling him to determine positively the intervisibility of the line Prospect–Otsego, and to discover a wooded summit near Mount Speculator, but still higher, the adoption of which would greatly improve and simplify the plan of work. Mr. J. B. Boutelle, extra observer, was at once dispatched to the locality of this summit, and found it to be one unknown to guides, tourists, or surveyors, and about five miles in a southerly direction from Speculator Mountain, about two hundred feet higher, and near a small lake called Lake Hamilton. A signal having been erected, observations were at once begun upon Hamilton, which was found to be well placed for a point intermediate between Prospect and Pen Mount. Progress at Otsego Station was much delayed by extensive forest fires to the north and west, so that at times the sun appeared as when seen through smoked glass. Observations having been completed on the 8th of September, Assistant Boutelle left Otsego on the 9th instant to join his party, who were preparing Hamilton for occupation. This station is near the town of Wells, Hamilton County, New York. It presented some difficulties of access, being six miles from any traveled road and in a dense forest. Camp was established at Lake Hamilton, one thousand eight hundred and twenty feet above the sea, and one thousand four hundred and thirty feet below the station, three miles distant. The instruments and accessories needed at the summit were sent up in mountain-carts over a "narrow-gauge" road cut through the woods. By the 21st of September Mr. Boutelle was in readiness to observe, but it was not till early in October that clear weather enabled him to make fair progress with the work. During the occupation of this station there occurred a remarkable case of deflection of a line of sight due to difference of temperature and density of the air occasioned by an intervening obstacle. To quote from Mr. Boutelle's report:

"The line Hamilton–Pen Mount is 72.5 kilometers long, and nearly due west in direction. Generally it runs from one hundred to seven hundred meters above the intervening country, the heights of the termini being nine hundred and ninety-four and five hundred and fifty-seven meters above the sea. About twenty kilometers westerly from Hamilton, the line *grazes* the tops of half a dozen tall trees upon the southerly edge of the summit of an isolated mountain near and west of Piseco Lake. I was obliged to set the heliotrope at Pen Mount at an excentric position in order to observe it in series until I could find and cut the trees, and refer the excentric point to the station by micrometric measures. The observations were made upon the heliotrope on three afternoons, and upon the magnesium light, occupying the place of the heliotrope, upon three evenings. The hours of observation were between two and five p. m. upon the heliotrope and between seven and ten p. m. of the same days upon the magnesium light."

The resulting angles with the reference mark were by observations on the heliotrope 30″.68, 32″.22, and 31″.00, and on the magnesium light 28″.58, 27″.12, and 27″.75, these being the means of five and six series observed each afternoon or evening, and presenting a mean difference of direction of 3″.49.

Remarking that there is no possibility of a difference in the observations on the reference mark by day or night, since the above observations upon Pen Mount were made both by day and night in series with other stations which show no such discrepancies, and with every other source of difference eliminated, Mr. Boutelle attributes this marked difference in direction to a bending of the line of sight from Hamilton around the isolated summit, and states that a similar anomaly was encountered in a line which he observed from Maryland Heights upon Peach Grove, Md.

The observations made at Hamilton from sunset to midnight upon stations showing the magnesium light signal were found to take the precedence in point of precision, the same degree of steadiness prevailing during that time upon all the lines as is found usually in day time only near sunset.

Toward the close of October, heavy rains set in, delaying the progress of the work. Observations were completed upon the 2d of November. Upwards of a week was occupied in getting the instruments and camp equipage off the mountain and out of the forest, owing to the injury done to the forest roads by the incessant rains. On the 12th of November, the party of Assistant Boutelle was disbanded, Messrs. J. B. Boutelle and T. P. Borden, Aids, being directed to report for duty at the Coast and Geodetic Survey office.

Geodesic leveling.—For the purpose of referring to the sea-level, the primary bench-mark of the line of transcontinental leveling which had been started westward from Hagerstown, Md., in 1877, Assistant Andrew Braid took the field early in July, 1881, and ran a line of leveling of precision from the bench-mark at Sandy Hook to Hagerstown. The point of departure at Sandy Hook was the bench-mark inside of the self-registering tide-gauge house, and the route followed thence was by way of the New Jersey Southern Railroad to Long Branch, and to Perth Amboy; thence, by way of the Lehigh Valley Railroad, to Bound Brook, N. J.; thence, by way of the New Jersey Central Railroad, to Easton and to Allentown, Pa.; thence to Reading and to Harrisburg, Pa., by way of the Philadelphia and Reading Railroad; thence, by way of the Cumberland Valley Railroad, to Carlisle and Chambersburg, Pa., and to Hagerstown, Md. From Sandy Hook to Hagerstown, by the route followed, the distance is four hundred and fifty-five kilometers, or two hundred and eighty-three miles. For the purpose of compensating cumulative errors, and obtaining a final result between these two stations freed from error as far as practicable, the method of leveling pursued was that of double simultaneous lines with alternate sections run in opposite directions. Tests were also made of the relative merits of this system as compared with single lines run in opposite directions, a distance of thirty-four miles being run in a forward direction, and re-run in an opposite direction over the same ground.

Three classes of bench-marks were established—primary, secondary, and tertiary. The primary benches, designated by letters of the alphabet, and the secondaries by Roman numerals, are intended for permanent marks, and are for the most part cut on public buildings or on piers of bridges. Occasionally, where this mode of marking was not practicable, resort was had to stone blocks or posts set in the ground, at a depth sufficient to be secure from the action of frost. The tertiary bench-marks designated by Arabic numerals were but temporary marks established as checks during the measurement.

Field operations were closed at Hagerstown on the 13th of December. During the winter and until April, 1882, Assistant Braid was engaged in bringing up to date the records and computations of his season's work. On the 5th of June he took the field again, with instructions which will be referred to under the head of Section XIV.

In Appendix No. 11 is given an investigation by Assistant Schott of the mean ocean level at Sandy Hook, to which the primary bench-mark of this line of transcontinental leveling is referred.

Geodetic operations in New Jersey.—Having availed himself of an early opportunity of beginning field operations, Prof. E. A. Bowser, Acting Assistant, had made a reconnaissance in Northern New Jersey before the opening of the fiscal year, with a view of extending the triangulation from the line Hamburgh–Bald Hill northeastwardly toward the boundary line between New Jersey and New York. The reconnaissance was rendered difficult by the number of mountain ridges of nearly the same height and all thickly wooded, but was satisfactorily accomplished, and on the first of July Professor Bowser had been for a month occupying Montana Station, in Warren County, the signals at Mount Olive, Pickles, Big Rock, and Smith's Gap having been readjusted and signals erected at Haycock and Culver's Gap. Heliotropes were subsequently found necessary at Culver's Gap and Big Rock.

The observations at Montana were completed August 15, and the party was transferred to Culver's Gap, Sussex County. Heliotropes were placed at Mount Olive and Montana, and a signal erected at High Point. This station, in the extreme northwestern corner of the State, was next occupied, the observations at Culver's Gap having been completed September 10. Signals were put up at Bear Fort Mountain, and on the 21st of October, the necessary observations at High Point having been obtained, field work was closed for the season. The statistics are:

Number of angles measured on primary stations	17
Number of angles measured on tertiary stations	29
Number of observations on primary stations	630
Number of observations on tertiary stations	171

Topography and triangulation.—For the continuation of the topography of the coast of New Jersey northward from the limits of his work of the previous season, Assistant C. M. Bache had taken the field before the opening of the fiscal year, and in the earlier part of the season was occupied in establishing the trigonometrical points needed before the plane-table work could be taken up. The triangulation, which was completed August 2, extended from Two-Mile Beach Station (2) to a point north of Townsend's Inlet. Of this part of the survey the statistics are as follows:

Number of stations occupied	8
Number of angles observed	30
Number of observations	762

The work on the topographical sheet includes that part of the New Jersey coast known on the old maps as Leaming's Beach, extending from Anglesea, at Hereford Inlet entrance, to a point south of Townsend's Inlet, and in the interior over the marshes and sloughs about Jenkins Sound to the cultivated land north and south of Cape May Court House. Field operations were closed November 16. The following are the statistics of the topography:

Shore line surveyed, miles	138
Roads, miles	30
Area of topography, square miles	18

Sub-assistant Joseph Hergesheimer served in the party from July 1 to the close of the season. During the winter, Assistant Bache was ordered to take charge of a topographical party in the vicinity of Norfolk, Va. His services there will be referred to under the head of Section III.

Hydrographic examinations for the Coast Pilot.—From July till October, 1881, Assistant J. S. Bradford was engaged in an examination of the inland waters between Delaware and Chesapeake Bays, with a view to collect data for the third volume of the Atlantic Coast Pilot, which includes these bays and the coast between them. Such incidental re-examinations of the waters of these bays were also made as were needful.

Upon the completion of this work, Mr. Bradford returned to the office and resumed duty in connection with the publication of the Coast Pilot. Subdivision 15, Atlantic Local Coast Pilot, which includes Delaware Bay, is now nearly ready for publication.

Hydrographic resurvey of Delaware Bay and River.—Lieut. H. B. Mansfield, U. S. N., Assistant Coast and Geodetic Survey, with his party, in the steamer Endeavor, was engaged at the opening of the fiscal year in a careful hydrographic resurvey of Delaware Bay and River. The working season of 1881 closed November 22, at which time two hydrographic sheets had been completed, the first one on a scale of 1–5,000, including that portion of the river from Cherry Island Flats to the range-lights on Deep-Water Point; the second on a scale of 1–10,000, extending from New Castle to a point below Fort Delaware on Pea Patch Island. A third sheet, scale 1–10,000, including the river from Reedy Island to a point near Thoroughfare Neck, was begun in August and partly finished by the close of the season; work upon it was resumed, and the sheet completed in May, 1882. The fourth sheet was finished during June, 1882. Its scale is 1–10,000, and it includes the river and bay from Bombay Hook Roads to Ship John Shoal.

The following named officers were associated with Lieutenant Mansfield in the work: Lieut. Hugo Osterhaus, U. S. N., Ensign Wm. H. Allen, U. S. N., and Ensign E. N. Fisher, U. S. N. The summary of statistics is as follows:

Miles run in sounding	698
Angles measured	6,921
Number of soundings	43,129

Hydrographic resurvey of Delaware Bay and River.—The scheme of work for this hydrographic resurvey was laid out so as to provide for a series of hydrographic sheets covering those portions of the river and bay not included in the projections furnished to Lieutenant Mansfield and alternating with them. The execution of this scheme was intrusted to Assistant H. L. Marindin, in charge of the schooner Ready. His series of sheets began at a point on the river just below League Island, and ended at Bombay Hook Roads. The working season of 1881 closed with the month of September, when the vessel was laid up for the winter, and Assistant Marindin reported for duty to Assistant Henry Mitchell, availing himself of the data collected in his hydrographic work to prepare, under Assistant Mitchell's direction, a comparison of the surveys of the Delaware River. In this work and in finishing the hydrographic sheets of the previous season, Assistant Marindin was occupied until early in May, 1882, when he made preparations to resume work on the Delaware River. Leaving Philadelphia on the 24th of May in the Ready, Mr. Marindin began his survey off Bombay Hook on the last sheet of the series, and was so engaged at the close of the fiscal year.

The results of this survey are shown upon six finished hydrographic sheets, four of them upon a scale of 1–5,000, and two upon a scale of 1–10,000. Five tide gauges were set up for the determination of the plane of reference for the soundings; permanent bench-marks were established at all the tide-gauge stations, and described in the records; the planes of reference were carried from one gauge to another by simultaneous observations of the range of tides.

Assistant Marindin had the aid of Engineer C. H. Amsden, and E. M. Katz, U. S. N., during the season of 1881. Sub-assistant W. I. Vinal joined the party at the opening of the season of 1882, and with Ensign Katz rendered very effective service.

The statistics of the work are:

Miles run in sounding	402
Angles observed	4,557
Number of soundings	21,672

A survey of the Delaware River made in 1819 by order of the councils of the city of Philadelphia has been compared with more recent surveys in a paper prepared by Mr. Marindin, and published as Appendix No. 15 to this report.

Triangulation of Delaware Bay and River.—In order to determine the positions of stations needed in the topographic and hydrographic resurvey of Delaware Bay and River, which was in progress at the opening of the fiscal year, Assistant S. C. McCorkle was instructed to take the field for the completion of the triangulation from New Castle to Cape May. With the aid of the old stations, it was thought that but few consecutive new stations would be required.

Finding that a number of large signals had been erected by the United States Engineer Corps for the purposes of their works of local improvement, and at or near the old Coast Survey points, Mr. McCorkle availed himself of these signals as far as practicable. Starting from the base Masonic Hall–Kelly's Point near New Castle, he continued down the river to the line Norny's–Stony Point below Reedy Island light. On making search for the points of Assistant Sullivan's triangulation of 1875, between Finn's Point and Port Penn, but five of them could be identified. The gale of 1878 had done great damage on the shores of the river, washing away in one place as much as twenty feet of solid ground. Mr. McCorkle remarks that above Bombay Hook the points located on sandy shores are apt to be lost by the action of the "sand-diggers." He had observed upon "Liston's" a very large signal in July, and in October it had disappeared and the sand hill with it. A vessel was moored along shore, taking in sand. Later in the season, Mr. McCorkle moved to Collins Beach Station, and subsequently proceeded to Fortescue Beach, whence he continued the triangulation down the Jersey shore as far as Cape May light-house, measuring an angle at this point also for the determination of azimuth. Following are the statistics of the work:

Number of stations occupied	22
Number of angles measured	150
Number of observations	1,800

As early in the season of 1882 as the appropriation would permit, Assistant A. T. Mosman took up this triangulation with instructions to push it to completion. Mr. W. B. Fairfield was ordered to report to him for duty as extra observer.

Topographic resurvey of the shores of the Delaware River.—In continuation of the topographic resurvey of the New Jersey shore of the Delaware River, Assistant R. M. Bache took up the work from the limits of that of the preceding season, beginning just before the opening of the fiscal year at Raccoon Creek, opposite Chester, Pa., and carrying it to Kelly's Point, opposite New Castle, Del. The survey is comprised in five sheets, upon a scale of 1-5,000, four of which were completed when the season closed; upon the fifth the shore-line was finished and part of the interior.

At the beginning of the season of 1882, Assistant Bache, having sent to the office his four completed sheets, resumed work upon the unfinished sheet of last season. For the fiscal year, the statistics are:

Shore line surveyed, miles	31
Roads, miles	30
Dikes, miles	18
Creeks and ditches, miles	80
Area of topography, square miles	9

Topographic resurvey of the shores of the Delaware River.—Assistant C. T. Iardella, at the beginning of the fiscal year, was engaged in continuing the topographic resurvey of the Pennsylvania and Delaware shores of the Delaware River, from the limits of his work of the previous season. His survey is comprised in five sheets, scale 1-5,000, extending from Chester, Pa., to New Castle, Del.

With reference to the character of the country, Mr. Iardella remarks that it is quite flat from Yarnall's Point in the vicinity of Chester for some distance in the interior, and up to the boundary line separating Pennsylvania from Delaware. After leaving this line the country in the vicinity of Claymont, Del., gradually increases in height from about sixty feet to one hundred and forty feet, and at Bellevue rises to three hundred and sixty feet, declining thence to Edgemoor, about three miles northeast of Wilmington, where it is perfectly flat, and remains so to the Christiana River. Between Christiana and New Castle there are, in some places, elevations of sixty feet. The statistics of the season's work, closing November 29, are as follows:

Shore line surveyed, miles	34
Roads, miles	63
Streets in New Castle, miles	8
Streams, miles	13
Creeks and ditches, miles	68
Area of topography, square miles	13

Assistant Iardella, towards the close of the fiscal year, made preparations for resuming this topographic survey.

Special triangulation.—In compliance with a request from the authorities of the city of Philadelphia, Assistant Spencer C. McCorkle was directed in January, 1881, to determine the position of the center of the new city hall, in that city. The center being in the court-yard, and the building not yet completed, Mr. McCorkle established an observing station upon the sixth floor of the south center pavilion, referring it to the center by the plans of the architect. Determining the position of his station from the lines Girard College–Commissioners Hall (Kensington), and Girard College–

New Presbyterian Hospital, he included in his plan a point on the bank of Belmont Reservoir, and also re-determined the observatory of the Central High School.

Assistant McCorkle expresses his obligations for facilities offered and aid supplied by Mr. Samuel L. Smedley, chief engineer and surveyor of the city, and by Mr. John McArthur, jr., the architect of the new city hall.

Geodetic operations in Pennsylvania.—Prof. Mansfield Merriman, Acting Assistant, having been directed to take charge of the triangulation of the State of Pennsylvania, completed the preparations necessary for taking the field early in July. He occupied in succession the stations Smith's Gap to the eastward of the Lehigh Water Gap and Beartown in Lancaster County, closing field operations on the 6th of September. The occupation of these two stations sufficed to correct errors in triangles depending upon them; which in measurements made in a former season had been found to exceed the limit of error admissible in work of this class. Having found that Blackspot Station was in danger of being lost, Professor Merriman established reference points, and made measurements needful to preserve its location. The records and computations of his work have been transmitted to the office.

SECTION III.

MARYLAND, VIRGINIA, AND WEST VIRGINIA, INCLUDING BAYS, SEAPORTS, AND RIVERS. SKETCHES NOS. 4 AND 6.

Hydrographic resurvey of Chincoteague Shoals.—At the beginning of the fiscal year, Assistant Gershom Bradford, with the party under his charge in the schooner Palinurus, was engaged in making a resurvey of Chincoteague Shoals, off the coast of Virginia, in order to develop the changes that had taken place since the survey of 1851, and to obtain data for a chart of these shoals showing their present condition.

Mr. Bradford found several marked changes. From a point about a mile and a quarter to the southeastward of Assateague light house, Fishing Point had extended nearly a mile and three-quarters in a south-southwest direction towards Ship Shoal, forming a cove or anchorage to the west. It seems probable that this extension is still going on, since a narrow ridge upon which are constant breakers makes out about fifty yards south-southwest from the end of the point.

The curves of least depth on Ship Shoal have moved southwestwardly, and from the comparison of the surveys and the testimony of the pilots there can be little doubt that minor changes are in progress in and near it. The nine-foot spot, bearing south a little westerly from the light-house, and known as Turner's Lump, has disappeared, and the shoal of which it formed a part has moved about half a mile westerly. The South Shoal, lying four and a quarter miles south of the light-house, has the same general form and direction as in the old survey, but has moved its whole length three-fourths of a mile to the westward, and a slight increase of depth was observed, there being nine and a half feet instead of nine as formerly. Changes of a minor character have taken place in Southeast Ridge, a shoal lying three and one-quarter miles south-southeast of the light-house.

Mr. Bradford determined the position of a black can-buoy, which was placed in position just before the resurvey to mark the South Shoal, the most dangerous of all. While the risk to vessels bound into Chincoteague Inlet, or under Fishing Point for shelter, is lessened, it is not wholly removed by the placing of this buoy, and Mr. Bradford recommends, therefore, that a danger buoy be placed one-fourth of a mile southwestward of the western end of the South Shoal. Practicable channels exist at present inside of the South Shoal and inside the Southeast Ridge, but in view of the changes that have occurred and are likely to occur in the stormy season, it is recommended in Mr. Bradford's report that vessels without a pilot be warned to avoid the inside passage, and that Ship Shoal buoy be changed from a red to a danger buoy as a further warning.

Tidal observations were made near the mouth of Chincoteague Inlet, and the plane of reference deduced was referred to that of the gauge at Chincoteague Island, established in 1880.

Mr. W. C. Willenbucher, draughtsman, temporarily detached from office duty for this work, rendered effective service. Statistics are as follows:

Miles run in sounding	260
Angles measured	2,137
Number of soundings	11,936

Mr. Bradford's report was accompanied by a sketch illustrating the changes between the present and former surveys. Upon the completion of the work July 16, 1881, he was ordered to duty which has already been referred to under the head of Section II.

Triangulation in the vicinity of Norfolk Harbor, Hampton Roads, and Elizabeth River.—Under instructions bearing date November 25, 1881, Assistant B. A. Colonna proceeded to Norfolk, Va., and made the necessary preparations for extending the triangulation in that vicinity in order to furnish points for the topography to be executed in the vicinity of Craney Island and Tanner's Creek, and for the hydrographic survey of Norfolk Harbor and Elizabeth River. Having searched in vain for stations of the former triangulation of that river, but two of which, exclusive of light-houses, could be found, Mr. Colonna erected signals preparatory to making a new triangulation, which he finally based upon the line of 1869, Newport News–Craney Island, east base. In connection with this work, he determined the geographical position of the new light-houses at the mouth of the Nansemond River and at Cape Henry, and furnished to the office a topographical sketch of the improvements at Fortress Monroe and at Newport News.

Mr. Colonna completed his work February 10, having completed the triangulation, and supplied all of the new points needed to the topographic and hydrographic parties. The statistics of the work are:

Stations occupied, number of	20
Points determined, number of	46

Experiments were also made in accordance with special instructions with a water-level upon seven vessels for the determination of the angular difference between the plane of flotation of a vessel at rest and when in motion. These experiments will be continued as opportunity offers, and the results will be made the subject of a separate report.

Upon leaving Norfolk, Assistant Colonna was directed to return to the office and resume duty which will be referred to under the head of Section XVII.

Continuation of topographical survey, vicinity of Norfolk.—Assistant C. M. Bache reached Norfolk, Va., February 14, 1882, with instructions to continue the topography of the vicinity of Norfolk from Fort Norfolk northward to Tanner's Creek. This portion of his work was finished April 12, and, in compliance with additional instructions, Mr. Bache filled in an unsurveyed spot near Ocean View; surveyed the right bank of Tanner's Creek below Indian Pole Bridge, and filled in the topography of the country on the western side of the Elizabeth River. He was engaged in this work, and had completed it except that part contained between the Western Branch of the Elizabeth River and Scotch Creek, when he was relieved from duty by Assistant E. Ellicott, to whom, on June 6, was transferred the charge of the party. The unfinished part of the survey, just named, was completed by Mr. Ellicott June 17, and the two topographic sheets, including the completed survey, were sent to the office.

Mr. Bache acknowledges the very efficient aid rendered by Mr. J. B. Boutelle, who served in the party until near the close of the season. Statistics of the work are:

Miles of shore lines surveyed	68
Miles of roads	67
Area of topography, in square miles	12

Hydrographic resurvey of Norfolk Harbor.—Lieut.-Commander E. B. Thomas, U. S. N., Assistant Coast and Geodetic Survey, to whom was committed the hydrographic resurvey of Norfolk Harbor, Virginia, arrived in that harbor in the steamer A. D. Bache December 19, 1881, and proceeded at once to execute the work. On the 14th of April, 1882, he reported the completion of the survey. The statistics are:

Miles run in sounding	168
Angles measured	2,811
Number of soundings	15,097

The results are shown upon two hydrographic sheets, including Norfolk Harbor and Elizabeth River, on scales of 1-5,000 and 1-10,000 respectively.

Lieutenant-Commander Thomas had the aid of the following-named officers: Lieut. C. C. Cornwell, U. S. N.; Master F. A. Wilner, U. S. N.; Master H. F. Reich, U. S. N.; Ensign E. M. Katz, U. S. N.; Ensign H. M. Witzel, U. S. N.; and Ensign J. M. Orchard, U. S. N.

Later in the season Lieutenant-Commander Thomas took up duty which will be referred to under the head of Section VI.

Hydrographic examinations for the Coast Pilot.—As already stated under the head of Section II, the inland waters between Delaware and Chesapeake Bays and the bays themselves were examined during that part of the fiscal year preceding October, 1881, by Assistant J. S. Bradford, with a view of collecting data for the third volume of the Atlantic Coast Pilot. Mr. Bradford's examinations were directed to all localities where he had reason to expect changes of importance either in topographical features, sailing directions, or positions of dangers, so as to bring the manuscript of the volume up to the latest date practicable previous to publication.

In this connection the office labors of the party under his charge may be referred to. In addition to the work on the third volume of the Coast Pilot, subdivision 3 of that work, including Penobscot Bay and tributaries, was revised, printed, and published in a new edition; subdivision 14, embracing the coast between New York and Delaware Entrance, was completed and published; twenty-six views of the coast were drawn and etched during the year by Mr. John R. Barker. This skillful draughtsman has completed in all one hundred and ten views for the Coast Pilot in a most satisfactory manner since his employment in this branch of the service. During the year he finished four views for the Topographical Manual under the direction of Assistant E. Hergesheimer.

Much time was devoted in the office by Mr. Bradford and his chief assistant, Mr. J. W. Parsons, to the revision and preparation for publication of the Table of Depths in the Harbors on the Atlantic and Gulf Coasts, a work involving great care and labor. The party was engaged, also, in the preparation of an elaborate article for the Light-House Board, showing the differences in names and geographical positions of points on the Atlantic and Gulf coasts between the publications of the Board and those of the Coast and Geodetic Survey.

Under the direction of Mr. Bradford, Mr. G. A. Morrison was engaged upon clerical duty during the year, chiefly in collating from Volumes I and II and arranging in convenient form the index for the forthcoming North Atlantic Coast Pilot (Eastport to Baltimore), which embraces within its limits Volumes I, II, and III of the first series.

Magnetic observations.—The usual annual determinations of the magnetic declination, dip, and intensity were made at the Washington magnetic observatory in charge of Assistant C. A. Schott. These observations were taken June 15, 16, and 17, 1881, by Assistant William Eimbeck, and the results indicate a conformity with the laws of secular change heretofore recognized. The observatory was also used by Lieut. S. W. Very, U. S. N., Assistant Coast and Geodetic Survey, to establish the constants of intensity for his magnetic work on the northeastern coast of America. Subassistant J. B. Baylor also made use of the observatory for testing instrumental constants.

Force of gravity.—Absolute determinations of gravity were made during the year at Cambridge, Mass. (see Section I), at Baltimore, Md., and at Washington, D. C. At Baltimore a series of experiments was made to determine the influence of the walls of the Geneva receiver upon the period of oscillation of a pendulum swinging within it. Four invariable reversible pendulums were made in the office upon a new pattern. The distance between the knife-edges of three of these is one meter, and for the fourth one yard. Mr. Peirce had the aid during parts of the year of Assistant Edwin Smith, and of Messrs. E. D. Preston and H. Farquhar.

In April, 1882, Major J. Herschel, R. E., of the India Survey, came to this country under the direction of his Government, to oscillate the Kater invariable pendulums at Hoboken, N. J., and at Washington, D. C., thus connecting the American pendulum work with the English. Advantage was taken of the presence of Major Herschel to hold an informal conference on the subject of pendulum work with special reference to its future prosecution in the Coast and Geodetic Survey by the most desirable methods, and by plans involving the greatest economy consistent with scientific accuracy. At this conference there were present, together with Major Herschel, the

Superintendent of the Coast and Geodetic Survey, and Assistants George Davidson, C. A. Schott, and C. S. Peirce, on the part of geodesy; and Professor Simon Newcomb, Superintendent of the Nautical Almanac, on the part of astronomy. Major J. W. Powell, Director of the United States Geological Survey (invited to attend on the part of geology), was unable to come. After an extended discussion, the conclusions arrived at having been formulated in several propositions and unanimously adopted, the conference adjourned. For a statement of these conclusions see Appendix No. 22.

Telegraphic longitudes.—At the opening of the fiscal year the longitude parties in charge respectively of Assistants G. W. Dean and Edwin Smith were established at Charlestown, W. Va., and Washington, D. C. At the instance of Assistant Dean, special instructions had been given by Mr. C. W. Smith, general manager of the Chesapeake and Ohio Railway, and by Messrs. J. W. Kates and David Flannery, superintendent and assistant superintendent of the Western Union Telegraph Company, to all operators on the line to afford every facility for the exchange of longitude signals, and notwithstanding the bad condition of a portion of the line, an exchange was effected on one night, but a severe storm followed, and immediately after that the continued occupation of all lines centering at Washington by the event of the 2d of July rendered it advisable to postpone the determination Washington-Charlestown to a more favorable opportunity.

Arrangements were at once made for determining the difference of longitude, Washington-Cincinnati, Assistant Smith conducting the operations at the Naval Observatory, Washington, and Assistant Dean those at Mount Lookout, Cincinnati. Between July 18 and 25 four nights were obtained for exchange of longitude signals; the observers then exchanged places, and completed the determination on five more nights between August 2 and 8.

In the longitude triangle, Cincinnati-Nashville-Saint Louis, the determination of which was next taken up, the longitude exchanges began on the line Cincinnati-Nashville, and will be referred to under Sections XIII, XIV, and XV.

Telegraphic longitudes.—In conformity with instructions dated near the close of the fiscal year, Subassistant C. H. Sinclair and Mr. F. H. Parsons began the preliminary arrangements for the determination of the longitude of a station at the University of Virginia, Charlottesville, by exchange of telegraphic signals from Washington. The details of the progress and completion of this work will be given in my next annual report.

Topography.—The detailed topographical survey of the District of Columbia, begun during the last fiscal year, at the request of the Commissioners of the District, was continued by Assistant J. W. Donn, with the aid during part of the year of Mr. W. C. Hodgkins, and of Subassistant D. B. Wainwright after the detachment of Mr. Hodgkins in June, 1882. At the close of the fiscal year ending with June, 1881, the work had been completed along Boundary Avenue from Lincoln Avenue to Sixteenth street, and as far north as the park of the Soldiers' Home, including the northwestern portion of those grounds. Much marginal work in the vicinity of Mount Pleasant Village, Seventh street road, and along the line of the Metropolitan Branch of the Baltimore and Ohio Railroad, between Terra Cotta Station and the Riggs road, was also shown upon the plane-table sheet. During July, August and September, the efforts of the party were directed towards the completion of sheet (No. 1) scale 1-4,800 between the north boundary of the Soldiers' Home and the northeast boundary of the District, and although progress was somewhat retarded by the difficulty of running contour lines in a country much covered by woods, orchards, and bushes, the whole area was completed with the exception of the portion lying to the north and southeast of Fort Totten, and that to the southeast of Fort Bunker Hill, these portions consisting mostly of woods. In order to advance without cutting through wooded areas, it was decided to postpone this part of the work till winter or early spring, when the trees were not in leaf. During the period between the beginning of October and the middle of February the survey was advanced southward from the Bunker Hill and Harewood roads, and was completed as to Sheet No. 1, the final work having been done in the complicated wooded areas of the Soldiers' Home and Glenwood Cemetery.

The Engineer Commissioner of the District then requested that, in view of the proposed extension of the Washington Aqueduct from its present terminus at the "Twin Reservoirs" to Meridian Hill, the survey of the route be at once taken up. A belt of topography, covering the line of the proposed extension, was finished between the beginning of March and the end of June.

This belt, half a mile wide, and limited by Sixteenth street on the east and the Tennallytown road on the west, included the most complicated and difficult work to be found in the District, a great part of the belt being covered by woods more or less dense. The lowest curve, at the creek running along the wall at the lowest part of Oak Hill Cemetery was ten feet; the highest was two hundred and thirty-five feet.

The further progress of this elaborate survey will be stated in my next annual report, and at a more advanced stage of the work statistics will be given. Photolithographs of the more important portions of the topography have been made from drawings in this office and furnished to the Commissioners of the District.

Topography.—The special topographical survey of the site for the new Naval Observatory in the District of Columbia, made at the request of Rear-Admiral John Rodgers, U. S. N., had advanced so nearly to completion at the beginning of the fiscal year, and its progress was so fully detailed in my last annual report, that any extended notice of it here may be omitted. The site selected is about three-tenths of a mile to the east of the Tenallytown road and upwards of half a mile north of the intersection of High and Road streets, Georgetown. Mr. Charles Junken conducted the survey with the aid of Mr. F. C. Donn.

Triangulation.—Having organized his party for the extension of the primary triangulation in West Virginia from the Blue Ridge towards the Ohio River, Assistant A. T. Mosman had completed the occupation of Ivy Station, in Raleigh County, at the opening of the fiscal year, and was directing the preparations needful for the occupation of Table Rock Station. Advantage was taken of delay in transportation, owing to unfavorable weather and bad roads, to make a reconnaissance for connecting the astronomical station at Charleston, W. Va., with the primary triangulation; one signal was erected at Creed, and a secondary station was established at Big Rocks, intermediate between the two primary stations, Holmes and Pigeon.

The instruments were mounted at Table Rock on the 13th of July, but progress being much delayed by rain and haze, it was not till August 15 that the requisite number of observations could be obtained. For horizontal direction five hundred and seventy-eight observations were made upon primary, and twenty-eight upon tertiary stations; one hundred and forty observations for difference of heights with the micrometer, and two hundred and ten measures of zenith distance with the vertical circle.

At the next station occupied in the primary scheme, Holmes, the needful preparations were completed on the 24th of August. During the interval between this date and the 29th of September every effort was made to overcome the unfavorable conditions of the atmosphere arising from heat and drought. Meanwhile station Creed was occupied by Mr. W. B. Fairfield, Aid in the party, and the work at Holmes having been finished at the date just named, the connection of the astronomical station at Charleston, W. Va., with the primary triangulation was taken up and completed early in October. At station Holmes seven hundred and thirty-seven observations of horizontal direction were obtained; seventy-seven observations for difference of heights with the micrometer, and one hundred and eleven measures of zenith distance with the vertical circle. At station Creed one hundred and fifty-two observations of horizontal direction, and at four other stations of the tertiary order in the vicinity of Charleston four hundred and seven observations of horizontal direction. Hence the field-work of the party while engaged in the primary triangulation and the operations immediately incidental to it and including the work at Ivy Station may be summarized as follows:

Primary stations occupied	3
Tertiary stations occupied	5
Observations of horizontal directions, number of	2,356
Micrometric differences of height, number of	300
Measures of zenith distance with the vertical circle, number of	417

Eight public buildings in the town of Charleston, W. Va., were determined in position.

During the rest of the season a reconnaissance west of the line Piney-Pigeon was begun for carrying the scheme of primary triangulation towards the Ohio River. Mr. Mosman found the country very much broken, being intersected by three considerable streams, the Mud River, Guyandotte River, and Twelve Pole Creek. The ranges of hills bounding these streams are nearly all of the same height, all densely wooded, and the courses of the streams themselves very crooked. Upon reaching the Ohio River early in November the party was disbanded and field operations closed.

Assistant Mosman makes special mention of the faithful and efficient service rendered by Mr. W. B. Fairfield, attached to the party as extra observer during the season. The records, field computations, etc., were all completed and forwarded to the office during the winter. Before the close of the fiscal year Assistant Mosman received instructions for field-work, which has already been noticed under the heading of Section II.

Special reconnaissance and triangulation.—In continuation of the explorations and surveys of the region between Washington, D. C., and Martinsburg, W. Va., for the purposes of a general map, Mr. H. F. Walling took the field towards the close of July, 1881. Obtaining the most trustworthy maps of Montgomery, Frederick, and Washington Counties, Maryland; of Loudoun County, Virginia, and of Jefferson and Berkeley Counties, West Virginia, Mr. Walling connected elevated points in that region by triangulation with stations already established in position, determined the heights of these points by a series of barometric observations referred to a fixed barometrical station, ran traverse surveys upon the roads for the purpose of comparing their actual lengths and directions with the configurations upon the maps, and verified the representations of railroad alignments by obtaining wherever practicable copies of the original notes or plans, giving the lengths and directions of the tangents, the lengths of the radii, and the lengths and directions of the curves. Where deficiencies existed in these notes special traverse surveys were made to supply them.

Along and near the mountain ridges and important hills different methods were pursued according to circumstances. In many cases lines were run by traverse along the summit of ridges, with accompanying barometer readings. Similar lines were also run up some of the valleys between the spurs. In other places less accessible, points were located and their heights determined by horizontal and vertical angles from known points along the roads in the valleys below. With the data and material thus obtained such portions of the county maps as were deemed sufficiently accurate for reduction to the projection were thus transfered to the general map. The area of its completed portion is as follows:

Washington County, Maryland (east of longitude 77° 58′), area in square miles	369
Frederick County, Maryland (entire), area in square miles	618
Jefferson County, West Virginia (entire), area in square miles	217
Total area of finished part in square miles	1,204

The area partly finished comprises portions of Berkeley County, West Virginia, and of Frederick, Clarke, and Loudoun Counties, Virginia, with an area of eight hundred and twenty-one square miles. It is estimated that between one-half and two-thirds of the work upon this area is completed.

Magnetic observations.—Subassistant James B. Baylor at the beginning of the fiscal year was engaged at Marion, Va., in completing the last station of a series for the determination of the magnetic declination, dip, and intensity in the States of Virginia and West Virginia. This magnetic tour was planned to include the occupation of a number of stations in Tennessee, Alabama, and Kentucky, and its further progress will be noticed under the heads of Sections XIII and VIII.

Geodesic leveling.—As already noticed, under the head of Section II, the primary bench-mark established at Hagerstown, Md., in the line of transcontinental leveling started westward from that point in 1877 was referred to the level of the sea by Assistant Andrew Braid, who took the field for that purpose early in July, 1881. His line of levels of precision began at the bench-mark of the self-registering tide-gauge at Sandy Hook, N. J., and ended at the bench-mark on the foundation of the court-house in Hagerstown. Reference will be made under the head of Section XIV to the extension of the line of levels of precision westward from Mitchell, Ind.

SECTION IV.

NORTH CAROLINA, INCLUDING COAST, SOUNDS, SEAPORTS, AND RIVERS. (SKETCH No. 5.)

Deep-sea soundings and temperatures.—In furtherance of the investigations relating to the physical features of the Gulf Stream, Commander J. R. Bartlett, U. S. N., Assistant Coast and Geodetic Survey, was engaged at the opening of the fiscal year in running lines of deep-sea soundings, with serial temperatures normal to the coast, between Currituck light-house, North Carolina, and Jupiter Inlet, Florida. With his party, in the steamer Blake, he had at the time just named completed nine lines of soundings, and on July 3 had anchored off the town of Smithville, N. C. Here he was detained by bad weather until July 8, and on getting to the northward of Cape Fear was compelled to make a harbor at Fortress Monroe, whence he sailed July 16, and next day ran a line of soundings normal to the coast in length about seventy miles, beginning off Currituck Beach light-house with a depth of ten fathoms and reaching eleven hundred and sixty-five fathoms in latitude 36° 13′, longitude 74° 18′. Upon this line, as upon those subsequently run, the record of depth sounded was accompanied by observations of the position of the steamer at each sounding, by observations of bottom and surface temperatures of water and strength and direction of currents, and by records of the character of the bottom from the specimens brought up, density of water, and meteorological phenomena. All soundings were taken with piano wire, using Commander Sigsbee's improved sounding machine. It always worked well, and his sounding cylinder never failed to bring up a specimen of the bottom. The temperatures below the surface were taken with the Miller-Casella deep-sea thermometers.

Additional lines were run off Cape Hatteras until July 20, and on July 22 a line from Cape Lookout to a depth of two thousand fathoms. On July 24 a line was run normal to the coast from a point about twenty miles to the eastward of Cape Fear and a return line to Charleston, where the Blake arrived July 28.

After a detention of some days by bad weather at Charleston, Captain Bartlett left that port early in August, and occupied the remainder of the season in running lines of soundings to test the working of the Siemens electrical deep-sea thermometer. This apparatus is described and figured in Appendix No. 18. Its principle depends upon the effect of changes of temperature in varying the resistance of metals to the passage of an electric current, and it consists essentially of two resistance-coils, one of which is lowered into the sea by means of a cable connecting it with the other resistance-coil on board ship. The end of the cable, which is in electrical connection with this resistance-coil, is attached to a "Wheatstone's bridge" with a battery and galvanometer. When the two coils are at the same temperature the galvanometer scale reads zero; any change in the temperature produced in the coil lowered into the sea causes a deflection to the right or left of zero; hence to ascertain the temperature of the coil at the bottom of the sea or of the water in its vicinity the coil on board ship must be heated or cooled till the zero indication is shown on the galvanometer scale. The temperature of the water in which this coil is immersed is then that of the water at the depth sounded.

Captain Bartlett has made a special report (Appendix No. 18) of the tests obtained with this apparatus, comparing the temperatures given by it with those of the Miller-Casella deep-sea thermometers. Serial temperatures, taken at intervals of five and ten fathoms from surface to bottom, showed a very gratifying accordance between the two methods, and led to increased confidence in the results obtained from the Miller-Casella thermometers.

With reference to the physical features of the area over which the Gulf Stream sweeps, the work of Captain Bartlett has developed some interesting results. His soundings show, not a deep channel, but, to quote from his report, "an extensive and nearly level plateau, extending from a point to the eastward of the Bahama Banks to Cape Hatteras. Off Cape Canaveral, nearly two hundred miles wide, and gradually diminishing in width to the northward until reaching Hatteras, when the depth is more than one thousand fathoms within thirty miles of the shore. This plateau has a general depth of four hundred fathoms, suddenly dropping on its eastern edge to two thousand fathoms."

Captain Bartlett remarks further: "It will be observed from the bottom specimens that the course of the Gulf Stream can almost be traced by the character of the bottom. On each side of the stream the sounding cylinder brought up ooze. In the strength of the current the bottom was washed nearly bare, the specimens being small broken pieces and particles of disintegrated coral rock. This bare portion was very hard, and the sharp edge of the brass sounding cylinder came up very much dented and defaced. From Jupiter Inlet, with the exception of the bare part mentioned, the specimens were a light-colored ooze composed of Pteropod shells, with a mixture of coral sand. Off Charleston, where the plateau has less depth than to the southward, the bare section extended the whole width of the stream. The Pteropod ooze extended only to Charleston. To the northward of that point the bottom specimens were Globigerina. To the northward of Cape Lookout and off Hatteras the bottom was Globigerina ooze of a dark greenish tint. (The specimens have changed color very much since first obtained.) These specimens of the bottom seem to me to throw very important light on the circulation. The Pteropods are brought along by the Gulf Stream. In the Caribbean Sea and Gulf of Mexico the bottom below three hundred fathoms is always Pteropod ooze. To the northward of Hatteras, and as far as the Georges Bank, we have found in the Blake only Globigerina ooze. The fact of finding Globigerina ooze off Hatteras, and its gradual diminution to the southward, would tend to show the limit of the Arctic current. The Globigerina were not found to the southward of the high part of the plateau off Charleston. It would appear from this fact alone, although the temperatures, I think, confirm it, that the Arctic current does not extend below Hatteras, but at this point goes under the Gulf Stream and to the eastward, being deflected that way by the form of the plateau. A number of lines were run off Hatteras to develop more fully this point. From Hatteras the one-hundred-fathom line gradually draws away from the shore as we go to the northward."

Allusion is again made in the report to the belt of rippling water off Charleston, near the center of the Gulf Stream, and the strong southwestern current found there. This "rip," Captain Bartlett states, is unlike any that he has ever seen, except the race at the entrance of Long Island Sound. He attributes it "to the sudden rise of the plateau off Charleston, together, probably, with the meeting of the Arctic current."

The statistics of work accomplished, from the time of leaving port, May 4, till the return of the Blake to Providence, August 17, are as follows:

Deep-sea soundings, number of lines run	18
Length of lines in miles	1,929
Number of soundings taken	337
Air temperatures observed, wet bulb	405
Air temperatures observed, dry bulb	405
Water densities observed	397
Water temperatures observed, surface	415
Water temperatures observed, intermediate	457
Water temperatures observed, bottom	334
Serial temperatures, number of	139
Current stations occupied with floats	28
Specimens of bottom, number of	257

The following-named officers, attached to the Blake, rendered efficient service during the cruise: Lieut. C. C. Cornwell, U. S. N.; Masters G. W. Mentz, Henry Morrell, and Lucien Flynne, U. S. N.; and Ensign E. L. Reynolds, U. S. N.

Hydrography.—For the purpose of locating a shoal reported by Captain Foster of the steamer Appold as about six miles east-southeast from Frying Pan light-ship, North Carolina, Lieut.-Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, proceeded to Smithville, N. C., in May, 1882, with his party in the steamer Gedney, and, having determined accurately the position of the light-ship, placed a buoy on the shoal in six fathoms water, the least depth found. This shoal is well known to the pilots and fishermen about Smithville; it has a general direction of north-northwest and south-southeast, and is nine miles in length, with a depth of from seven to eight fathoms. The location of the buoy is nine and one-fourth miles from the light-ship, from which it bears east 12° south (magnetic).

Lieutenant-Commander Brownson remarks that since New Inlet was closed, the water on the bar of Seward Channel leading into Cape Fear River has deepened, and eighteen feet can now be carried over at high water.

SECTION V.

SOUTH CAROLINA AND GEORGIA, INCLUDING COAST, SEA-WATER CHANNELS, SOUNDS, HARBORS, AND RIVERS. (SKETCH No. 7.)

Hydrography.—A shoal having been reported ten miles northeast by east from Georgetown light, coast of South Carolina, by the master of a coasting schooner, Lieut.-Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, was directed to make careful search for it. This duty was performed April 27, 1882, under conditions very favorable for showing the existence of shoal water, but Captain Brownson could find no indications of it, and reports that, according to his judgment, no such shoal exists. He suggests that the master of the schooner was out in his position, and that what he actually saw was the shoal spot (seventeen feet of water) off Georgetown light, with Cape Romain bearing southwest distant about ten miles.

Upon the completion of a hydrographic survey on the Florida coast, which will be referred to under the heading of Section VI, Lieut.-Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, was directed to proceed to Port Royal, S. C., for the purpose of making such examinations of the Beaufort River as would determine what portions needed resurvey. The bed of the river is of phosphate rock, and is constantly being dredged, the rock having valuable properties as a fertilizer. Upon conference with Capt. J. E. Jouett, U. S. N., commanding the naval station, Lieutenant-Commander Brownson found it advisable to make an immediate survey of a small portion of the river opposite to Battery Creek. This work was accomplished between the 14th and the 22d of April.

Tidal observations.—Application having been made by Lieut. B. D. Greene, United States Engineers, through General Q. A. Gillmore, U. S. A., for the loan of a self-registering tide-gauge to be established at Fort Sumter, Charleston Harbor, South Carolina, in connection with the works of construction in progress there, the gauge was forwarded to him soon after the beginning of the fiscal year. The tidal curves will be sent for tabulation and discussion to this office.

SECTION VI.

PENINSULA OF FLORIDA, FROM SAINT MARY'S RIVER, ON THE EAST COAST, TO ANCLOTE KEYS ON THE WEST COAST, INCLUDING THE COAST APPROACHES, REEFS, KEYS, SEAPORTS AND RIVERS. (SKETCHES Nos. 8, 9, 10, AND 11.)

Deep-sea soundings.—As previously stated under the head of Section IV, Commander J. R. Bartlett, U. S. N., Assistant Coast and Geodetic Survey, at the opening of the fiscal year had completed nine lines of deep-sea soundings with surface and bottom temperatures. His first line was run from Memory Rock, Little Bahama Bank, to Jupiter Inlet light, Florida, and was followed by a series of lines normal to the coast, of the character and with the results already fully stated. These investigations, so valuable as a contribution to our knowledge of the phenomena of the Gulf Stream, will be resumed at the earliest date practicable.

Triangulation, topography, and hydrography of Indian River, E. Fla.—With instructions for the extension of the survey of Indian River southward from the limits of the work of the preceding season, Assistant C. H. Boyd arrived at Turkey Creek on the 24th of January, 1882, and taking charge of the sloop Steadfast, brought her southward about forty-five miles, reaching a locality which served as a base of operations early in February. The three classes of work were then taken up from the limits of 1881, and carried forward continuously till the last of April, the triangulation beginning at the line "Eggs" to "May" in latitude 27° 40′ north; the topography at station "Guest," a mile and a quarter north of that line, and the hydrography at station "Narrows" nearly a mile above "Guest."

Progress was less rapid than had been anticipated on account of the wide and dense fringe of wooded swamp on the east side of the lagoon, entirely cutting off all view of signals on the ocean beach sand-dunes from those on the shores of the lagoon. At the "Narrows" the mangroves became large trees. Tripod signals and scaffolds were found necessary, elevating the theodolite twenty-two feet.

To bring the shore-line within view of the plane-table, the instrument had to be placed far out in the water, and the telemeters were carried by boat, so dense was the belt of mangroves fringing the eastern shore of the lagoon. The work was pushed forward energetically, however, until about eighteen miles of the lagoon and ocean beach had been covered by the triangulation; one topographic sheet scale 1-20,000, ending at Indian River Inlet, completed, and the topography on the upper end of the next sheet well advanced. From the ocean beach the entire island forming the eastern side of the river is covered by the topography, and enough of the western shore to delineate its characteristics fully.

The hydrography covers the lagoon from a point about two miles north of the triangulation to Indian River Inlet. The waters are shoal, with many islands, oyster and sand bars obstructing its navigation. Four tide-gauges were established for the reduction of the soundings, the most permanent of which is upon the wharf at Saint Lucie post-office, referred to a bench-mark on Mr. Paine's house.

Towards the close of April, and in accordance with instructions, Assistant Boyd furnished a tracing of the shore-line and the geographical positions determined as far as the inlet, to the officer charged with the execution of the off-shore hydrography, and for the purpose of establishing additional points southward, began on the 3d of May a beach measurement with twenty-five meter steel tapes. On the 20th of May a point had been reached on the ocean beach upwards of thirty-one miles from Indian River Inlet, and in sight of Jupiter Inlet light. The season's work was then closed, the Steadfast being laid up in a sheltered position in the fresh water of Manatee Creek at the mouth of the Saint Lucie River.

Assistant Boyd makes acknowledgment of the efficient service rendered by the officers of the party, viz: Subassistant J. B. Weir, and Messrs. Carlisle Terry, Geo. F. Bird and E. S. Taney, Aids. All original and duplicate records of the work have been deposited in the office. The statistics are as follows:

Number of geographical positions determined	35
Number of directions measured	850
Number of horizonal angles measured	2,674
Ocean beach shore line, number of miles	43
Lagoon or river shore line, number of miles	112
Shore line of creeks, number of miles	10
Area of topography, square miles	21
Number of miles of soundings run	132
Number of soundings	16,928

Hydrography, east coast of Florida.—For the continuation of the hydrography of the east coast of Florida to the southward from the limits of work of the preceding season, Lieut.-Commander E. B. Thomas, U. S. N., Assistant Coast and Geodetic Survey, with his party in the steamer A. D. Bache arrived off that coast in the vicinity of Indian River Inlet early in May, 1882. The two projections furnished to him included the coast between the limits of latitude 27° 45′ and 26° 55′ north. Work was at once begun upon the upper projection, and completed upon both of them towards the end of June.

During the progress of the survey a dangerous shoal, the existence of which was known, but not its exact locality, was developed by Lieutenant-Commander Thomas. He describes it as follows:

"This shoal (Saint Lucie) is three and one-half miles from the land, and is in latitude 27° 18′ 30″ north; longitude 80° 08′ 45″ west. It is a narrow ridge extending north and south for about one mile, the least water on it being fifteen feet. From the center of the shoal, Mount Elizabeth bears south 53° 08′ west (true) and House of Refuge No. 2 on Saint Lucie Rocks bears south 7° 48′ west (true). Mount Elizabeth is a round-topped hill sixty feet high, on the west side of Indian River in latitude 27° 15′ 10″ north; longitude 80° 13′ 50″ west. It is the highest land in the vicinity, and is easily recognized if seen from a point to seaward of the shoal. But from a less distance from the shore the hill is not visible, as it disappears behind the trees on the beach.

"Deep water (ten fathoms) is found from six hundred to seven hundred yards to seaward of the shoal. As the numerous steamers, passing to the southward, run in quite near this shoal in endeavoring to avoid the current of the Gulf Stream, I think a whistling buoy should be placed in the vicinity."

A correction was made by Lieutenant-Commander Thomas in the position heretofore given for Jupiter Inlet light.

Acknowledging the zeal and efficiency of the officers of his party, viz, Master Frank A. Wilner, U. S. N., and Ensigns H. M. Witzel, J. M. Orchard, C. S. McClain, U. S. N., Lieutenant-Commander Thomas presents the following statistics of the work:

Miles run in sounding	884
Angles measured	3,721
Number of soundings	21,410

The results are shown upon two finished hydrographic sheets, scale 1–40,000, which have been sent to the office.

Hydrography of Key West Harbor and Northwest Channel Bar.—For the purpose of ascertaining the exact locality of changes which had taken place in Key West Harbor and vicinity, Lieut. Commander W. H. Brownson, in the steamer Gedney, made an examination of that harbor and of a portion of Northwest Channel in April, 1882. He reports but little change in the harbor since the last survey, but a decided change in the bar of Northwest Channel, owing to a gradual extension of the east bank to the westward, which makes a change in the location of buoys necessary. No indication was found of a shoal within the limits of "The Triangles." One finished hydrographic sheet, showing the results of the work, has been forwarded to the office. The statistics are:

Miles run in sounding	472
Angles measured	5,292
Number of soundings	20,906

Triangulation between Charlotte Harbor and Tampa Bay.—The completion of the triangulation and beach measurement between Charlotte Harbor and Tampa Bay, on the west coast of Florida, was assigned to Subassistant Joseph Hergesheimer, under instructions dated December 26, 1881. Mr. Hergesheimer arrived in New Orleans early in January, and having made the necessary repairs to the schooner Quick, he anchored in Tampa Bay towards the close of February, after a very long passage, due to calms and adverse winds. Thence he proceeded to Little Sarasota Inlet, from which locality as a base of operations he completed the beach measurement and triangulation southward for a distance of fifteen miles. Changing his anchorage first to Stump Pass and then to Charlotte Harbor, the work was completed to the line of the old triangulation "Gasparilla–Trepador," at both of which stations the granite monuments marking them were found to be in good condition. Thirty-five miles of coast line were covered by the triangulation and beach measurement. With regard to this portion of the coast, Mr. Hergesheimer remarks:

"There is but one anchorage (for the vessel) between Little Sarasota and Gasparilla, a distance of thirty-five miles. This is Stump Pass, a small inlet which can be entered by a sailing-vessel under the most favorable circumstances only, as the bar and channel are constantly changing. There is about six feet of water on the bar. It is not safe to attempt to enter any of the small inlets on this coast with a vessel drawing over five feet of water without first going ashore and making an examination of the bar, as every heavy westerly wind seems to change the bar and channel. At 'Little Sarasota' the channel is not over twenty-five meters wide, bounded on one side by ledges. Three years ago, when I took the Quick into this inlet, the channel passed to the southward of the ledges, but this season I found the channel to the northward, with the old channel entirely filled up."

Statistics are as follows:

Angles measured, number of	83
Observations, number of	1,453
Distance measured on beach, in meters	13,286

Upon closing work the schooner Quick was laid up at Manatee, Fla., and Subassistant Hergesheimer was directed to proceed to Washington and report at the office.

SECTION VII.

PENINSULA OF FLORIDA, WEST COAST, FROM ANCLOTE KEYS TO PERDIDO BAY, INCLUDING COAST APPROACHES, PORTS, AND RIVERS. (SKETCH NO. 12.)

Hydrographic survey of the inner and outer bars of East Pass, Saint George's Sound.—During the winter of 1881-'82, Lieut.-Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, was engaged in a number of localities on the west coast of Florida for the purpose of filling gaps in the hydrography and of making new surveys where demanded by changes of importance. Referring to his work in geographical order, the hydrography of the inner and outer bars of East Pass, Saint George's Sound, was executed between the 6th and 14th of February, 1882. Upon his arrival off East Pass, Lieutenant-Commander Brownson found a large Norwegian barque aground on the bar, and immediately answered a call from her for help, succeeding in hauling her off inside the bar. This barque was drawing eighteen feet of water, and went to sea the same night with nineteen feet on the bar. Upon the outer bar the survey showed seventeen and one-half feet at mean low water, and there was noted a marked extension of Dog Island Point and of the east end of Saint George's Island. The statistics of the work are as follows:

Miles run in sounding	34
Angles measured	492
Number of soundings	1,874

Hydrography in the vicinity of Saint Joseph's Bay and Cape San Blas, Fla.—For the development of the hydrography off the coast of Florida, between Cape Saint George and Cape San Blas, and thence northwestward in the vicinity of Saint Joseph's Bay, Lieutenant-Commander Brownson, with his party in the steamer Gedney, left Pensacola on the 22d of November, 1881, and having established a tidal station at Saint Joseph's Point, began work upon his projections December 5, and prosecuted it at every interval of favorable weather till the 1st of February, when the survey was completed. The weather was very unfavorable during the whole of the month of January, fogs and haze being prevalent most of the time.

With reference to the configuration of that portion of the Gulf of Mexico plateau off Cape San Blas, Lieutenant-Commander Brownson remarks that to the northward of the cape it is very regular; to the southward very irregular, the soundings indicating an extremely undulating bottom. Six miles to the southwestward of San Blas he found a shoal spot not given on any chart with a least depth at mean low water of twenty-two feet. And to the southward of this (seven and one half miles south by west ½ west of the cape) another shoal with a least depth of twenty-four and one-half feet, both shoals being of but small extent.

Some facts of interest observed during the survey are stated as follows in Lieutenant-Commander Brownson's report:

"The current between Capes Saint George and San Blas sets to the northward and westward with a velocity of from one-quarter to one-third of a knot per hour. At one time, while at anchor eight miles south of San Blas, with the surface current setting to the northward and westward thirty-five hundredths of a knot per hour, a fishing line over the side showed a strong current setting to the eastward, a heavy sinker being repeatedly carried in that direction. The observation for surface current at the time was made with a loaded staff nine feet in length. The coast line in the vicinity of Cape San Blas is gradually wearing away. The light-house is now surrounded by water at high tide, and I have been informed that at times the keeper has been unable to enter.

Miles run in sounding	545
Angles measured	932
Number of soundings	5,581

Hydrography of the bar of Pensacola Harbor.—Lieut.-Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, took command of the steamer Gedney on the 1st of October, 1881, and after some delay on account of bad weather began on the 10th of that month the hydrography of the bar of Pensacola Harbor, with special examinations of the changes that had taken place since the earlier surveys. On the 21st of November the work was reported as complete, and the finished hydrographic sheet, with records accompanying, was forwarded to the office. The following extracts from the report of Lieutenant-Commander Brownson embody statements of some of the more noteworthy results of the survey.

"The shoals and bars at the entrance of the harbor are of sand. In running the lines of soundings, mud was reported by the leadsmen in several places, but on taking specimens of the bottom, it was found to be soft sand. There is now a least depth of twenty-two and one-half feet on the outer bar, while on the inner bar (extending between the lower end of Middle Ground and Cancus Bank) the least depth in the channel is twenty feet, with twenty and one-half feet on either side of it. This shoal with twenty feet is probably what has been known among the pilots and tug-men as the '21-foot lump.' I also note the gradual extension of the western end of Santa Rosa Island, and the washing away of the coast in the vicinity of Fort McRae, the new shore-line being over one hundred meters inside of old line.

"In order to prevent the further washing away of this shore, and to restore it, if possible, and also to increase the depth of water on the inner bar, a series of jetties are in course of construction, extending normal to the shore-line above and below Fort McRae, about five hundred feet out in the channel.

* * * * * * * *

"Since the last survey a new channel has been opened, with eighteen and one-half feet of water between the Eastern Bank and Santa Rosa Island, about three hundred meters from the latter. It is narrow, however, and of no importance at present. I experienced much difficulty in getting the observations for currents, twenty-five hours being necessary for a complete series at each station. The tidal currents are very irregular and depend in a great measure, both for velocity and direction, on the wind. With moderate weather from the southward, the sea breaks on Cancus Bank and the Middle Ground."

SECTION VIII.

ALABAMA, MISSISSIPPI, LOUISIANA, AND ARKANSAS, INCLUDING GULF COAST, PORTS, AND RIVERS.

Magnetic observations.—In the course of the magnetic tour, made by Subassistant J. B. Baylor, in 1881, the determination of the magnetic elements at two stations in Alabama was included. Mr. Baylor observed for magnetic declination, dip, and intensity at Decatur and Florence, Ala., and determined also the latitude, longitude, and azimuth at these stations for magnetic purposes. Reference has already been made to his work under the head of Section III, and it will be referred to again under the head of Section XIII.

SECTION IX.

TEXAS AND INDIAN TERRITORY, INCLUDING GULF COAST, BAYS, AND RIVERS. (SKETCH NO. 14.)

Triangulation, topography, and hydrography between Galveston Bay and Sabine Pass.—Under instructions dated December 26, 1881, Assistant F. W. Perkins organized a party for the survey of the coast of Texas between Galveston and Sabine Pass, the principal objects of the season's work being the determination of points along the shore for the outside hydrography, together with a topographical survey of the shores and a hydrographic survey of the entrance to Sabine Pass.

All preparations having been completed towards the end of January, including repairs to the schooner Research, the work was begun at Bolivar Point while awaiting the arrival of the vessel and camp-equipage, Colonel Mansfield, of the Engineer Corps, having kindly placed his quarters at the disposal of the party. A measurement by wire was made of the beach of Bolivar Peninsula, about eighteen miles in length, for the determination of hydrographic points, and a reconnaissance was made in the vicinity of High Island. Upon the arrival of the Research in February, the triangulation was begun, using as a base the line Peirce–Northwest Bend, these being the only two points of the old triangulation that could be identified. Points in the back country were determined from the shore triangulation by concluded angles, care being taken to obtain as many separate determinations as possible, and to supply long lines for carrying azimuths.

As soon as enough points had been fixed by the triangulation, which was steadily pushed eastward towards Sabine Pass, the topography was begun, a separate party with a light camp having been organized for this purpose. Upon the completion of the triangulation and topography, the inner portion of the Sabine Pass, not liable to radical changes from the works of construction in progress on the bar, was sounded, and a reconnaissance was made to the eastward of the Pass. The many difficulties encountered in the work owing to the marshy character of the country, the limited means of transportation available, and the hazy state of the atmosphere were successfully surmounted by the skill and energy of Mr. Perkins and his Aids, Messrs. C. H. Van Orden and Isaac Winston. The topography and a large part of the triangulation were executed by Mr. Van Orden. He had also a share in the beach measurement. Special mention is made by Mr. Perkins in his report of Mr. Winston's exertions in determining, with the aid of Mr. R. E. Duvall, foreman in the party, the shore-line of a very dangerous stretch of coast west of the entrance to Sabine Pass, and known as the "Oil Pond." It had been considered impassable and unapproachable either from the water or land sides, being in great part a bed of mud so soft that in many places even the beach birds and cranes sink in it to their breasts.

The survey was completed early in the month of May. Its statistics are recapitulated as follows:

Number of geographical positions determined	54
Number of pointings made	8,481
Shore-line surveyed, miles	55
Roads and creeks, miles	58
Area of topography in square miles	66
Miles run in sounding	16
Angles measured	204
Number of soundings	2,382

The computations and records have been forwarded to the office.

Triangulation, base measurement, and topography, vicinity of Laguna Madre, Tex.—Having received instructions to resume the survey of the coast of Texas from the limits of his work of last season, Assistant R. E. Halter established his camp at Flour Bluff, near the head of Laguna Madre early in October, 1881, and took up the topography of that part of the shores of the lagoon. He took advantage of weather unfavorable for topography to clear the line of the base of verification which it was proposed to measure in the spring, and to erect the signals at the stations needed to connect the base with the triangulation. The plane-table work was prosecuted until the close of March, 1882, when the contact-slide base apparatus having been received, and all preparations made for the measurement, it was begun on the 3d of April, the first measurement being from north base to south base, and the second one in the opposite direction. By the 19th of April the two measurements had been completed, the results showing a close agreement. The azimuth of the line was determined by observations on Polaris near eastern elongation. Mr. J. E. McGrath served acceptably as Aid in the party. Statistics of the work are as follows:

Miles of shore-line surveyed	198
Area of topography, in square miles	60
Horizontal angles, number of observations	786
Azimuth, number of observations on star	88
Azimuth, number of observations on mark	44
Length of base-line in meters	5,486.9

Mr. Halter has forwarded to the office the topographic sheets and other records of the survey.

SECTION X.

CALIFORNIA, INCLUDING THE COAST, BAYS, HARBORS, AND RIVERS. (SKETCHES NOS. 15, 16, 17.)

Selection of site for permanent magnetic station.—In co-operation with the work of the Signal Office, and with that of the International Polar Commission, it became desirable to establish a magnetic observatory at some point near the southern coast of California; and in order to select a site that would most completely fulfill the conditions demanded, Assistant J. S. Lawson was directed in May, 1882, to examine localities at and near San Diego and Los Angeles. In pursuance of this duty he left San Francisco June 7, and having carefully investigated the several sites in the vicinity of the towns just named, decided in favor of the grounds of the Branch State Normal School in Los Angeles as meeting fully the essential requirements of the observatory, viz, a location that would secure permanency for several years; freedom from local disturbing influences such as any moving masses of iron or metal and any large fixed masses of iron; freedom from vibrations or jarrings of passing vehicles; a free supply of pure water; certainty that no buildings were to be erected or iron pipes laid near the observatory; convenience of living for the observer, and economy in construction of the building.

Permission to occupy the grounds for the purpose in view having been given by Governor Geo. E. Perkins, of California, representing the Board of Trustees of the State Normal School as its president *ex officio*, Mr. Lawson began the work of construction at once in accordance with the plans furnished by the office, with some needful modifications suggested by himself. The instruments to be set up were the Adie magnetographs, which register by photography, and for their more effective working require the maintenance of as uniform a temperature as practicable and freedom from currents of air; two buildings, one inner, one outer, were therefore constructed with a space of about two and a half feet between the walls, the piers for the self-registering magnetic apparatus being placed in the inner building. The details of construction are fully stated in Mr. Lawson's report, which is accompanied by a plan of the observatory and maps showing its location in Los Angeles.

For the usual absolute determinations of the direction and intensity of the magnetic force made on three days of each month, Mr. Lawson established a station at a sufficient distance from the differential instruments, and upon the arrival of Mr. Werner Suess, who was charged with the fitting up of the observatory and apparatus, he left Los Angeles under instructions to take charge of the primary triangulation northward of Point Concepcion.

Reconnaissance and primary triangulation between Point Concepcion and Monterey.—For the extension of the primary triangulation of the coast of California from Point Concepcion northward Assistant Stehman Forney organized his party at the beginning of the fiscal year. Having readjusted the signals at stations "Gaviota" and "Lospe," and erected signals at stations Arguello and San Luis, at heights ranging from fifteen hundred to three thousand feet, Mr. Forney started on a reconnaissance to the northward and eastward, with a view of determining the intervisibility of a station intended to connect directly in the scheme with "Lospe" and "Tepusquete."

A careful examination having shown the impracticability of the scheme as originally proposed, it was modified so as to adopt the figure Lospe, Tepusquete, San José, Castle Mountain, and Rocky Butte, with San Luis as a central point, the intervisibility of the line Rocky Butte–Lospe, fifty-eight miles in length, having been established. From Castle Mountain and the stations which connect immediately with it, "Castor" and "Santa Lucia," prominent peaks of the Sierra Nevada, are visible.

After erecting and adjusting the signals needed, Mr. Forney occupied Tepusquete Station towards the end of August, remaining there till early in October. The observations made for horizontal and vertical angles were, however, not satisfactory, owing to the hazy and smoky state of the atmosphere. Hence the principal result of the season's work was the advancement of the triangulation by establishing a practicable scheme for the connection of the primary triangulation of the coast northward of Point Concepcion with that of the Sierra Nevada. With regard to the best season for prosecuting this work, Mr. Forney expresses an opinion in favor of the period from the first of November to the first of June, and states that heliotropes will be necessary on all but the shortest lines.

Topography from San Luis Obispo northward.—A topographical survey of the coast of California, from Point Caballo to Point Buchon, under the direction of Assistant W. E. Greenwell, was in progress at the date of the opening of this report. Early in July, 1881, one plane-table sheet was completed, and work was begun upon a second, extending from Point Buchon to Moro Rock. The character of the topography was partly mountainous, partly sand-dunes, covered with low brushwood or chaparral. In connection with the plane-table survey, and for its proper elaboration, a triangulation was carried forward from the line Schumacher–Pecho northward. Field operations were closed early in October, and during the winter the two topographic sheets and the records and computations of the triangulation were forwarded to the office. Statistics of the work are as follows:

Number of signals observed upon	66
Number of observations	2,094
Miles of shore line surveyed	19
Miles of roads	13
Area of topography, in square miles	6

Tidal observations.—Under the direction of Assistant George Davidson, the records of the self-registering tide-gauge at Saucelito, near the entrance to the Bay of San Francisco, have been continued by Mr. E. Gray. The record has been maintained without interruption, and the station is one of much importance, being now the only one of the kind on the Pacific coast. A series of meteorological observations is kept up in connection with the tidal record.

Topography between Balenas and Table Mountain.—At as early a date in 1882 as the season would permit, the topography needed to fill the gap between Balenas and Table Mountain was completed by Subassistant E. F. Dickins, under the direction of Assistant Davidson, the two former surveys being joined in the best practical manner. The topographic sheet has been forwarded to the office.

Supplementary topography of San Francisco Bay and approaches.—Important changes having taken place in the shores of San Francisco Bay entrance, in the wharf-lines of the city, and in the topography of the surrounding country since the earlier surveys, it became desirable to obtain data and material for additions and corrections to the published charts, by the execution of supplementary topography, with such triangulation as became necessary in the progress of the plane-table work. This duty was intrusted to Assistant L. A. Sengteller, who organized his party at the beginning of the fiscal year. Having made four projections, covering the Tamalpais Peninsula, he repaired to Saucelito July 12, and began field operations, continuing the topographic survey until October 14, at which date the entire Tamalpais Peninsula had been completed, and a fifth sheet projected, including the towns of San Rafael and San Quentin. At Point Bonita, where by the courtesy of Colonel R. S. Williamson, United States Engineers, and Captain G. W.

Coffin, U. S. N., the party occupied temporary quarters at the light-house, a complete resurvey of the Point was made, it having been reduced and much changed as compared with former surveys.

Tracings of the five sheets were put in hand just before the completion of the work, and also a sketch for reduction by pantagraph to the scale of publication of the chart (1–40,000). These were all forwarded to the office before the close of the field-work.

The party was next transferred to the eastern shore of San Francisco Bay. But three stations of the old triangulation could be recovered; hence an auxiliary triangulation was begun, covering the shores of Contra Costa and Alameda Counties, and determining all points needed in the city of San Francisco, and on the islands in the harbor. By the 10th of November a sufficient number of points had been obtained to resume the topography; both triangulation and topography were then pushed to completion, and the work on the eastern shore of the bay brought to a close January 25. At this time three more topographic sheets had been finished, and to complete the work of the supplementary survey there remained to be executed a thorough examination of the entire water front of the city, and of the shores of the San Francisco peninsula to Point Lobos and southward towards Merced Lake. This work was taken up in the spring, the party being engaged during the winter in office work upon the topographic sheets and records.

On the 15th of April, the party having been reorganized, a projection (two sheets joined) was prepared, including the shore-line from Point San José (or Black Point) to Point Avisadera, and the topography of the city front begun. At the same time all authentic data that could be obtained from local sources bearing upon the work of the survey was collected. Assistant Sengteller acknowledges his obligations for valuable maps and documents to Capt. C. F. Humphreys, U. S. A., to the city and county surveyor, W. P. Humphreys, esq.; to F. A. Bishop, esq., chief engineer of the State Harbor Commissioners; and to the engineer of the Golden Gate Park. Such of the maps obtained from these sources as were of sufficient accuracy were reduced to a scale of 1-10,000, so as to be made more available for the field-work. Two additional projections, extending from Point San José to Point Lobos, and thence as far south as the Ocean Side House, being soon in readiness, work was begun upon them without delay. Upon the sheet first named, all needed topography was finished May 31, and upon the other sheets June 22. Instructions having in the mean time been received for a hydrographic examination of the city front, and of Oakland Creek and its approaches, this was begun June 25, and had nearly reached completion at the close of the fiscal year.

During that part of the season previous to April 15, Messrs. Fremont Morse and P. A. Welker served as Aids in the party, the former during the entire season, the latter from November 1. Assistant Sengteller expresses his high appreciation of the good judgment and ability displayed by Mr. Morse in the execution of the triangulation, which was rapidly accomplished. Mr. Morse was assigned to other duty at the reorganization of the party in April, Subassistant E. F. Dickins reporting for duty at the same time, and taking charge of one of the plane-tables. To Messrs. Dickins and Welker Assistant Sengteller expresses his thanks for hearty and constant co-operation and support. Statistics of the work are as follows:

Geographical positions determined, number of	36
Angles observed, number of	290
Observations, number of	4,948
Miles of shore line surveyed	52
Miles of roads	168
Area of topography in square miles	6
Miles run in sounding	81
Angles measured in sounding	969
Number of soundings	6,003

Coast hydrography between Bodega Bay and Point Arena, Cal.—For the continuation of the hydrography close to shore of the coast of California between Bodega Bay and Point Arena, to the northward and westward from the limits of preceding work, Lieut. W. T. Swinburne, U. S. N., Assistant Coast and Geodetic Survey, organized his party on board the steamer McArthur, and began work July 17 by establishing a tidal station at Bodega Bay, referring the gauge to a bench-mark already established. By the close of the season, October 20, three hydrographic sheets had been completed, showing soundings on lines of an average length of three miles from the coast, in depths ranging from four feet to fifty fathoms, and having limits as follows: Stengel triangulation station to Bourne's Rock; Bourne's Rock to Schooner Gulch, and Schooner Gulch to Point Arena. Lieutenant Swinburne was aided by Lieut. L. C. Heilner, U. S. N., Master W. P. Elliot, U. S. N., Midshipman W. V. Bronaugh, U. S. N., Midshipman F. V. Bostwick, U. S. N., and, during part of the season, by Ensign William Braunersreuther, U. S. N. Statistics of the work are:

Miles run in sounding	330
Angles observed	2,293
Number of soundings	6,948

After the completion of the survey to Point Arena the McArthur was laid up at the Mare Island navy-yard.

Measurement of Yolo Primary base-line.—Preliminary examinations, made by Assistant George Davidson, for the selection of a site for a primary base-line in California date back to the year 1876. The general location having been fixed, upon the plains of Yolo County between Cache and Putah Creeks, in that part of the Sacramento Valley lying immediately east of the Vaca or Berryessa Mountains (a spur of the Coast Range), Assistant Davidson directed his special examination towards finding a site for the line which should form the best and most practicable connection with the scheme of primary triangulation extending eastward across the continent, and northward and southward along the Pacific coast.

After a careful reconnaissance, occupying but a few days, the line was in that year provisionally located, and a quadrilateral established, the eastern points of which were Northwest Base and Southeast Base, and the western stations Monticello and Vaca, peaks of the Berryessa Mountains.

As finally established in 1880, the line lies nearly parallel with that part of the California Pacific Railroad joining the towns of Davisville and Woodland, in Yolo County, and is between three and four miles to the west therefrom, its general direction being north 16° 53′ west. It crosses the streams and sloughs running eastward across the Sacramento Valley. (See illustration 28.) These streams and sloughs, which are dry in summer, carry large volumes of water and are subject to overflows in the rainy season; the effect of these overflows has been to raise their banks gradually from some distance on either side, so that the stream may be said to run on a ridge. Cache Creek (Rio Jesus Maria), having the great equalizing reservoir of Clear Lake as its source, does not present this feature in a marked degree, but Putah Creek (Rio de las Putas), Anderson, Dry and Willow Sloughs do. On the south side of Cache Creek bottom there is a ridge of favorable elevation, thirty-five feet. Upon this ridge Northwest Base was located, four and one-third miles west of the railroad, and immediately on the north side of the county road running west towards Madison and Copay Valley. Southwest Base, distant 10.9 miles by the line, is three and one-eighth miles west and one and one-eighth miles south of the town of Davisville. Levelings between the two ends of the base, with a reference to the bench-mark of the California Pacific Railroad at Woodland, gave for the elevation of Southeast base 71.26 feet above low-water of the Pacific, and for Northwest Base 153.28 feet; hence Northwest Base is higher than Southeast Base 82.02 feet. It is intended to check this provisional determination by a line of levels of precision to be carried from Southeast Base to the Coast and Geodetic Survey bench-mark at Benicia.

At the opening of the fiscal year in July, 1881, preparations for the measurement were actively begun; bridges or high trestles were constructed for crossing the sloughs: the grading of the line was pushed forward; a comparing beam and a steel rod for fractional measure were constructed; a movable cover or tent was made to shelter the base apparatus during the measurements and comparisons; the alignment was made, and signals were set up to be tested from the two ends of the base. The line lies through a farming district noted for its rich soil, and therefore every acre had been under cultivation. Where the crop had been harvested during the season the high stubble was cut down close to the ground, which then presented all the irregularities left by the farmer. Two-thirds of the line, however, passed over fallow land where the ground had been plowed in the spring and in some places had been roughly harrowed. In the work of grading, a roller with cutting-disks was passed over this land to break up the rough clods and in part make it more compact. Many difficulties were presented, however, by the dry, baked soil, permeated in not a few places by deep and extensive cracks found to exist below the plowed stratum.

Upon the arrival of the base apparatus, near the end of July, brick-cemented piers were built at camp, near the middle of the line and also near each end, upon which to make the comparisons of the bars with the field standard. It had been decided in January, 1880, that the construction of an additional primary base apparatus was advisable, in view of the necessity of measuring several primary base-lines upon the Pacific coast and within the Rocky Mountain region. In order to secure for the survey an apparatus which should combine accuracy, rapidity of measure, ease of handling, facility of transportation with least risk of derangement, and especially one that should require the least amount of grading or other preparation of the ground for measure, Assistant C. A. Schott was directed to submit plans which should fulfill as many of these conditions as practicable; and on March 1 of that year he proposed the construction of a compensating base apparatus composed of two measuring-bars, each five meters in length, and submitted his design for the apparatus, with a description and complete working drawings prepared under his direction by Mr. Werner Suess, mechanician. Though it presents no novelty in principle, yet in the arrangement and combination of the parts it is novel, as will be seen by the full description and drawings which Mr. Schott has given in Appendix 7 and illustrations Nos. 26 and 27.

Each measuring-bar consists of two overlapping steel bars, firmly fixed to a zinc bar, making a return connection between the two former, the forward end of the zinc bar being riveted to the forward end of the rear steel bar, and its rear end to the rear end of the forward steel bar. The three bars thus form but a single one, composed of two metals so proportioned in length that the greater expansion or contraction of the zinc bar in one direction is exactly met by the smaller expansion but greater length of the steel bars moving in the opposite direction.

In the construction of the apparatus the specific heat of the two metals and their surface exposure was studied, and a secondary compensation for holding the apparatus firmly on the rear trestles, and thus keeping the rear end at an invariable distance from the trestle support during the measure, is applied in a simple way, using the T rail and steel bars as one metal and the two zinc bars as the other. Some minor improvements which may be here referred to are: The manner in which the aligning telescope is adjusted to the bar; the use of a knife-edge turning about a vertical axis on the rear trestle, with a corresponding comb of teeth below the bar for holding it firmly; the use of portable bed-plates for the feet of the trestle, etc. There is also a ring covering the contact-slide which allows it to be fixed during comparisons for length.

Although thermometers are supplied to the apparatus, each end of the compound rigid bar is provided with a Borda or differential scale. Belonging to the apparatus are two standard five-meter bars to be used in comparisons, one for the field, the other for the office. These standards consist of a central steel bar with two zinc bars of half the length of the steel bar, one on each side of it, and fastened near the abutting ends. Two Borda scales are secured at the middle of each bar. This arrangement is supposed to be a novel feature. The plan also involved the construction of two screw-level comparators after the pattern of Repsold. The design of the apparatus was submitted by direction of the Superintendent to Assistant Davidson for criticism, and his suggestions in some minor details of construction were adopted.

Unavoidable delays took place in the actual work of construction in 1880, and it was not till near the close of June, 1881, that the two measuring bars, the two standards, and trestles were completed. During the winter and spring, observations were made for co-efficient of expansion of the various standard meters needed for the adjustment of the length of the five-meter standard bars; these meters were of cast-steel, and their ends were armed with platinum iridium plugs.

It had been intended to make a practical test of the apparatus in the field before sending it to the Pacific coast, but for this there was no time after its completion. The base-bars were first practically used to lay off a line of one hundred meters for a wire-measurement of the line. At the end of each one hundred meters a stub was firmly driven into the ground, and properly marked, these measures serving as checks against the possible error of omitting to count any bar, or of counting it twice. The result of this wire-measurement came within six-tenths of a meter of that by the apparatus. After a test of the working of the bars upon a preliminary line of five hundred meters in length, the actual measurement of the base was begun September 19. "Fence stones" had been placed in line at all the east and west section lines, and at one or two other points, in order to give checks on the work, and to afford checks hereafter, as being likely to be less disturbed at the fences. Kilometer stones were carried forward and planted during the first measurement, whenever the bar indicated one thousand meters, without regard to any reductions for inclination, etc. The ends of the base had been secured and marked in the most permanent manner in 1880. For a description and sketch of the granite monuments at the ends, and of the precautions observed in marking, see Appendix No. 8 and accompanying illustrations.

As organized for the measurement, the chief of the party, Mr. Davidson, had the aid of Assistant J. J. Gilbert, of Subassistants H. W. Blair, E. F. Dickins, J. F. Pratt, of Werner Suess as mechanician and of C. B. Hill as recorder. Fourteen men were employed on the line while the work was in progress. Every officer and man had a specific duty assigned to him. The measurement went forward with comparative slowness at first, increasing in rapidity as practice made easier the manipulation of the apparatus. Mr. Davidson plumbed end of bars, aligned and leveled after end of bar, made and broke contact, read the after-Borda scale, and started the general forward movement by giving the word "Break" when the contact-slide of the forward bar was drawn back, and the after-bar was drawn back, lifted out, and moved forward. Mr. Gilbert assisted in adjusting sectors, then directed the laying of the plates and setting the trestles. Mr. Blair aligned the bars, read forward Borda scale, and checked reading for inclination. Mr. Dickins moved after-end of bar into line, read after-thermometer and the inclination; then guarded the bar left in position. Mr. Pratt prepared the bars for comparison with the standard, assisted in the comparisons, made fractional bar measurements, and examined sectors. Mr. Suess made such mechanical changes as were necessary, and had charge of moving the portable cover. The records of measurement and of comparison were kept by Mr. Hill.

Assistant C. A. Schott was present before the beginning of the first measurement, and remained until its successful progress was assured. His intimate knowledge of the peculiarities of the apparatus and his advice and suggestions as to its proper handling were of great value at the outset. His aid was given in the preliminary comparisons, and in the preparations for measurement generally. Assistant B. A. Colonna had rendered efficient service in the grading and preparation of the line up to the 8th of September, when he was ordered east for special duty which will be referred to under the headings of Sections III and XVII. The trestle bridges and platforms for crossing streams and sloughs were from his plans, and were constructed under his direction.

Each day, before the measurement began, the bars were compared with the standard bar in the condition in which they had remained overnight. Then the sectors were examined by the leveling instrument, for the determination of the zero of the inclination arc. The after-bar was then plumbed over the night-mark, and at its satisfactory measurement the command "Break" announced the forward movement of the bars.

The first measurement, starting from Northwest Base, was made in twenty days; the total hours at work were one hundred and eighty-two and one-half, and during the measurements alone one hundred and seventeen hours. The highest number of bars in one day was two hundred and seventy-one; the average number one hundred and seventy-five. The average time for each bar was two and one-eighth minutes; the average number of bars per hour twenty-eight, and the highest number thirty-nine.

After the close of the first measurement the bars were compared with the standard hourly for one day, and some changes were made in the details of the aligning telescopes; these were subsequently much improved by Mr. Pratt.

The second measurement was carried forward in the same direction as the first, and was completed in eighteen days. The total working hours were one hundred and seventy-one and one fourth, and the actual time occupied in measuring was ninety-three and one-half hours, a gain of very nearly a day over the actual working time of the first measure. The highest number of bars in one day was two hundred and seventy-six; the average number one hundred and ninety-four. The average number of bars per hour was thirty-seven, and the highest number forty-nine.

Eight days were occupied in a third partial measurement, during which the highest rate of speed was attained, an average of forty-three bars per hour being measured, and during one of the days fifty-four per hour. In one of the hours of this day fifty-seven bars were measured, and during the whole day three hundred and twenty-four bars or 1.01 miles.

Upon the completion of the measurements the apparatus was brought to camp, and adjusted on the comparing-beam for comparisons with the standard. These comparisons were continued hourly for fifty hours. The bars and standard were then taken to San Francisco. Assistant Davidson has made a full report of the measurement, which will be found in Appendix No. 8, with illustrations numbered 28, 29, and 30.

During the winter Mr. Davidson was engaged in office work, and in work on the Coast Pilot. Under his direction all of the Yolo base records were examined, duplicated, and forwarded to the office; preliminary reductions were also made and transmitted. In the office work of his party he had the aid of Assistants Lawson, Gilbert, and Forney, and of Subassistants Dickins and Pratt. Mr. Lawson was engaged for a short time after his return from a magnetic tour in California, Oregon, Washington Territory, and Idaho in the computation and duplication of his season's work. Until relieved on the 30th of April to prepare for field-work on Puget Sound, Mr. Gilbert was occupied specially upon the records of the Yolo base, drawings for illustrating the report of measurement, etc. Mr. Forney was assigned to the party in February, and until relieved at the end of June, was engaged upon his work of the previous season. Mr. Dickins assisted in the current work of the office until relieved April 15. Mr. Pratt gave special attention to the study of improvements in the aligning telescopes of the base apparatus; drawings illustrating his plans have been sent to the office. He also prepared the primary station at Table Mountain for occupation, and opened a road to the top, part of which, for a mile and a half over the main ridge involved much labor through rocks and chaparral. Concrete piers were built for the theodolite, transit, zenith telescope, and vertical circle.

This work was accomplished during the absence of Mr. Davidson in Washington, whither he had been summoned for special duty early in April, and where he remained for nearly a month after the close of the fiscal year. During his stay in Washington, Mr. Davidson was appointed by the Transit of Venus Commission to take charge of one of the parties for the observation of the Transit of 1882, at a station in the United States.

Primary triangulation and reconnaissance of the north coast of California.—Towards the close of August, 1881, Assistant A. F. Rodgers had completed the occupation of King's Peak, one of the stations of the primary triangulation of the north coast of California. He had observed the final directions needed to connect Great Caspar Station with Sanhedrim, Cahto, and Lassac, and had received instructions to revise the reconnaissance northward from the line King Peak–Lassac, and to determine a practicable scheme as far north as Point Saint George, near Crescent City. In the scheme, as originally laid out, Elk Ridge had been included, but it was found subsequently that an intervening range of hills made the line King Peak–Elk Ridge invisible, and the line Elk Ridge–Lassac doubtful.

Reducing his camp equipment and instrumental outfit to the smallest compass, Mr. Rodgers visited the Rainbow Mountains, North and South Taylor's Peak, Wild Cat Ridge, Bear River Ridge, Humboldt Hill, Mad River, Ki-wett, and other peaks and ridges of the Coast Range. Many of these summits were heavily timbered, and north of Humboldt Bay mountain trails afforded the only means of communication. The statement given by Mr. Rodgers of the distances and elevations (by barometer) on the journey from Humboldt Bay in a northeasterly direction to Ki-wett will illustrate some of the difficulties of the reconnaissance, and explain the delays unavoidably met with before the scheme was finally developed:

"Distance from Humboldt Bay to Ki-wett by trail, sixty miles. At five miles from the Bay crossed Mad River at one hundred feet elevation, and at ten miles passed over Sisson's Hill at a height of two thousand feet above tide; at thirteen miles from the Bay, and at a height of four hundred feet, crossed the West Fork of Mad River; at twenty-two miles, passed over Elk Prairie Ridge three thousand six hundred feet in height; at twenty-eight miles crossed Redwood Creek, seven hundred feet, thence down the bed of the creek to an elevation of five hundred feet; then at thirty-eight miles over Wire Grass Ridge, at a height of three thousand feet; at fifty miles crossed the Klamath River, elevation one hundred and ninety feet, and at sixty miles climbed to the summit of Mount Ki-wett, four thousand two hundred and fifty feet."

Owing to stormy weather, the ascent of this mountain was made three times from the Klamath River, before the needed observations could be obtained.

Early in December, after a close study of the country, with the data made available by his reconnaissance, Assistant Rodgers submitted a scheme for the development of the north coast triangulation from the line, King Peak–Lassac through three quadrilaterals to the line Point Saint George's–Preston's Peak. This scheme will provide for a connection between its eastern stations and the western stations of the transcontinental triangulation, and will serve also to check the determinations of the tertiary triangulation along the coast.

Magnetic observations at stations between San Francisco, Cal., and Sitka, Alaska.—For the purpose of determining the absolute values of the magnetic declination, dip, and intensity at a number of stations on the Pacific coast between San Francisco and Sitka, Lieut. Commander H. E. Nichols, U. S. N., Assistant Coast and Geodetic Survey, organized his party on board the steamer Hassler early in July, 1881. He was provided with the following named instruments: theodolite magnetometer No. III; dip circle (Wurdemann) No. 10, and altazimuth (Fauth & Co.) No. 128; also with a sextant and artificial horizon for determinations of the geographical positions of the stations.

Having occupied the "Presidio" of San Francisco as a station of reference and comparison, the Hassler left that port July 14, and after a cruise of three months in the waters and along the coasts of British Columbia, Alaska, and Washington Territories, returned to San Francisco in October. "Presidio" Station was reoccupied October 31. Additional reference to the work of Lieutenant-Commander Nichols is made under the heads of Sections XI and XII.

SECTION XI.

OREGON AND WASHINGTON TERRITORY, INCLUDING COAST, INTERIOR BAYS, PORTS, AND RIVERS.

(SKETCHES Nos. 17 and 18.)

Triangulation, topography, and hydrography of the Columbia River.—Assistant Cleveland Rockwell was in the field at the opening of the fiscal year, acting under instructions which directed him to continue the survey of the Columbia River from the limits of former work near Kalama and Saint Helen's towards Vancouver and Portland. Having organized his party upon the sloop Kincheloe, and partly completed the hydrography of the river above Kalama, the further prosecution of this part of the work was postponed on account of the high stage of water, and the triangulation taken up from the line Table Cliff–Lewis River Hills, above Saint Helen's. At Scappoose Station, one of the first occupied during the season, a great deal of cutting and burning of heavy timber had to be done to open lines of sight. This was the case also at station Willamet, on the west side of the Willamet River. By the 12th of October the scheme of secondary triangulation was completed to the line Balch–Trecon Rocky Butte in the vicinity of Portland.

The hydrography was then resumed, and by November 24 soundings were completed from the vicinity of Kalama to Columbia City. Bench-marks for reference of the soundings had been established at Martin's Island and Saint Helen's, in connection with the tide-staffs set up at those stations, and after the close of the season Mr. Rockwell fixed bench-marks at Kalama and Rainier of a more permanent character. This done, the Kincheloe was laid up for the winter at Albina, near Portland. Statistics of the season's work are as follows:

Angles measured in triangulation	181
Number of observations	11,414
Miles run in sounding	163
Angles measured	2,368
Number of soundings	10,355

In June of the present year (1882) Assistant Rockwell re-organized his party for the continuation of the survey of the Columbia River and its chief tributaries. Before the close of the month a reconnaissance had been made and signals erected for the triangulation of the Willamet River and arrangements were nearly complete for beginning the topography of the valley of the Columbia from the line Reed-Scappoose, above Saint Helen's.

Magnetic observations.—In order to obtain additional data required for the construction and publication of a new edition of the Magnetic Chart of the United States, and for the discussion of the secular change of the magnetic declination, Assistant J. S. Lawson was detailed, at the opening of the fiscal year, to occupy a number of stations in Oregon, Washington Territory, and Idaho, including in their number stations at which the magnetic elements had been determined from ten to twenty years before. His instrumental outfit consisted of a theodolite magnetometer, a dip circle, and a three-inch alt-azimuth instrument (Casella) for determinations of azimuth and geographical position. Having made a complete set of observations at the base station, San Francisco, Mr. Lawson began his journey thence on the 13th of July. On his return in December, he had occupied twelve stations in Oregon, twelve in Washington Territory, and three stations in Idaho. Included in this number were the following named principal or secular change stations: Portland, Astoria, and The Dalles, in Oregon; Walla Walla, Wallula, Seattle, and Port Townshend, in Washington Territory; and Siniaquotem, in Idaho. Upon the completion of this work Assistant Lawson was directed to report for duty at the sub-office in San Francisco. His field-work in Section X before the close of the fiscal year has already been referred to.

Magnetic observations.—The magnetic cruise of the steamer Hassler, under the command of Lieut.-Commander H. E. Nichols, U. S. N., Assistant Coast and Geodetic Survey, has been referred to already under the heading of Section X. Two stations in Washington Territory, Nee-ah Bay and Cape Disappointment, were occupied in the course of the cruise at dates respectively of October 10 and October 13. Other magnetic determinations at stations in Alaska and British Columbia will be mentioned under the head of Section XII.

Triangulation and topography in Puget Sound.—Assistant Eugene Ellicott, to whom had been assigned the topographic survey of the shores of Port Orchard, one of the inlets of Puget Sound, prosecuted that work until its completion towards the close of September, 1881, and then took up the triangulation of Hood's Canal. The weather during the remainder of the field season proved exceptionally unfavorable for observation. The close proximity of the Olympic Mountains to the locality of work, Mr. Ellicott thinks, had a tendency to emphasize the bad weather which prevailed so constantly. Early in December field operations were closed, and, in accordance with subsequent instructions, Mr. Ellicott reported for duty upon the Atlantic coast.

Hydrography of Port Discovery and Washington Harbor.—At the opening of the fiscal year, 1881-'82, Lieut. Perry Garst, U. S. N., Assistant Coast and Geodetic Survey, in command of the schooner Earnest, was engaged in a hydrographic survey of Port Discovery, one of the inlets of Puget Sound, Washington Territory. His instructions involved a limit of work, including Washington Harbor, and extending out to and around Protection Island and Dallas Bank, thence eastwardly towards Point Wilson, and westwardly to Kulo Kala Point. The hydrography within these limits was completed on the 10th of October, and the vessel was then laid up for the winter at Olympia. Statistics are as follows:

Miles run in sounding	438
Angles measured	3,226
Number of soundings	9,461

Lieutenant Garst had the aid of Ensigns H. T. Mayo and J. A. Jordan, U. S. N.

SECTION XII.

ALASKA, INCLUDING THE COAST AND THE ALEUTIAN ISLANDS. (SKETCH No. 19.)

Magnetic observations and hydrographic reconnaissance.—The plan of the magnetic cruise undertaken by Lieut. Commander H. E. Nichols, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Hassler, included magnetic observations at a number of stations on the shores of Alaska and British Columbia, as already referred to under the heads of Sections X and XI; it involved also hydrographic examinations of a few of the more frequented and least known straits and anchorages in Alaskan waters. Between July 29 and October 5, determinations of the magnetic elements were made at nine stations in British Columbia and at the following named four stations in Alaska: Shakeen, Port Wrangel, Howcan, and Sitka. In Ward's Cove, at the western end of Tongas Straits, a dangerous ledge was developed with a least depth on it of three feet at low water. A hydrographic reconnaissance of Wrangel Straits for the benefit of the mail steamers was completed on the 30th of August. At the request of the Rev. Sheldon Jackson, and with official approval, a survey and reconnaissance was made from Cape Muzon through Kaigahnee Straits to Tlerak Narrows. The records of these surveys have been forwarded to the office, and will be available for the new edition of the Coast Pilot of Alaska, now in preparation. In October the Hassler arrived at San Francisco and completed her magnetic cruise, Lieutenant-Commander Nichols having reoccupied the base-station "Presidio" October 31. During the winter all of the magnetic records and results were finished and sent to the office, and at the date at which this report closes Lieutenant-Commander Nichols is again in the waters of Southern Alaska with the Hassler, engaged in hydrographic surveys, having left San Francisco under instructions for that work in May, 1882.

Tidal observations.—Tidal records and tabulations from the self-registering tide-gauge established at Saint Paul, on Kadiak Island, Alaska, have been regularly received at the office. This gauge, put up in July, 1880, upon the wharf of the Alaska Commercial Company, was placed in charge of Mr. W. J. Fisher. A series of meteorological observations is kept up at the tidal station.

SECTION XIII.

KENTUCKY AND TENNESSEE. (SKETCHES Nos. 20 and 21.)

Determination of the longitude of Nashville, Tenn.—The organization of the telegraphic longitude parties and their work in Section III has already been referred to. Upon the completion of the determination of the longitude of Cincinnati by telegraphic exchanges from Washington, D. C., as stated under the heading of that section, the party of Assistant Dean was transferred to Nashville, Tenn., while Assistant Smith remained at Cincinnati. The instruments were in position at Nashville on the 18th of August, and all arrangements made for exchange of signals, but a week of unfavorable weather followed and before an exchange could be effected, Assistant Dean was taken severely ill, and was obliged to give up the charge of his party temporarily to Subassistant C. H. Sinclair.

Between August 25 and 29 four good nights were obtained; the observers then changed places, and four nights were obtained between September 1 and September 6. For the determination of the latitude of the station at Cincinnati, observations were made by Subassistant Sinclair with the transit-instrument No. 4, which had been fitted with a micrometer and delicate level for use as a zenith telescope. The occupation of Saint Louis, the third station in the longitude triangle, Cincinnati–Nashville–Saint Louis, will be referred to under the heads of Sections XIV and XV.

Triangulation of the State of Kentucky.—In continuation of the triangulation of the State of Kentucky, Mr. Carl Schenk, Acting Assistant, took the field early in July, 1881. The first station occupied was "Williams," a station in Indiana, which connected directly with the ends of the base measured in Kentucky, and was common also to four quadrilaterals, extending from the Ohio River in the vicinity of New Albany and Louisville to a point south of Salt River, a tributary of the Ohio which empties into it at West Point. Owing to the hazy condition of the atmosphere during July and August, and also to the smoke from the factories of Louisville, New Albany, and Jeffersonville, it was found necessary to establish heliotropes at the principal stations observed upon from Williams, namely, Bangs and Potts, in Indiana, and Cox, Riley, Mountain Top, and Blind Asylum, in Kentucky. Measurements of horizontal angles at Williams were completed September 22, and at Potts—the next station occupied—on November 1. Preparations for the occupation of Bangs Station, located on the river hills north of New Albany, Ind., were in progress when orders were received to close work for the season. The records and abstracts of the work have been forwarded to the office.

Triangulation of the State of Tennessee.—At the opening of the fiscal year, Prof. A. H. Buchanan had been occupied for a month in making a reconnaissance for the extension of the triangulation in the central part of the State of Tennessee. By the end of July signals had been erected at four primary and four secondary stations. Two of the primary stations, Chestnut and Walker, were near the western edge of the table land of the Cumberland Mountains, and will ultimately connect with stations in the Crab Orchard range, from which the scheme of triangulation can be carried towards Knoxville. During the season, which closed October 24, two primary stations were occupied: "Short Mts." and "Chestnut." Much unavoidable delay was caused by unfavorable weather. The statistics are:

Lines of horizontal direction observed	11
Lines of vertical direction observed	11
Number of observations of horizontal directions	363
Number of observations of vertical directions	275

Magnetic observations.—In the course of the magnetic tour made by Subassistant Jas. B. Baylor in 1881, he occupied eleven stations in Tennessee, and ten in Kentucky, for the determination of the magnetic declination, dip, and intensity. At each of these stations the latitude, longitude, and an azimuth were observed for magnetic purposes. Mr. Baylor has sent to the office the original and duplicate records and the computations of his observations.

SECTION XIV.

OHIO, INDIANA, ILLINOIS, MICHIGAN, AND WISCONSIN. (SKETCHES Nos. 4–22 and 23.),

Telegraphic longitudes.—The determination of the longitude of two of the stations in the longitude triangle, Cincinnati–Nashville–Saint Louis, has already been referred to under the headings of Sections III and XIII. Upon the completion of the longitude exchanges between Cincinnati and Nashville, the party at the latter station moved to Saint Louis, and Assistant Dean, having recovered from his illness, resumed the charge of the work at Cincinnati.

Longitude signals were exchanged on four nights between September 12 and September 21; the observers then changed places, and four more nights were had between September 23 and October 5. The two sides of the triangle having thus been determined directly, viz, Cincinnati–Nashville, and Cincinnati–Saint Louis, the next determination was that of the third side, Nashville–Saint Louis. This was followed by exchanges of signals for the longitude of Vincennes, Ind. These operations will be mentioned in detail under the heading of Section XV.

Geodetic operations in Ohio.—In continuation of the triangulation of the State of Ohio, Prof. R. S. Devol, Acting Assistant in the Coast and Geodetic Survey, resumed field-work about the middle of July, 1881. A scheme of triangulation having been developed during the previous season, with stations located in the counties of Athens, Vinton, and Hocking, Professor Devol put up observing tripods and scaffolds at seven stations, and on the 17th of August occupied Mount Nebo Station, in Athens County. Owing to an excessive and long-continued drought, and the prevalence of extensive forest fires, a hazy condition of the atmosphere was produced very unfavorable to rapid progress, and it was not till the 30th of September that the observations at Mount Nebo were completed.

The party was then transferred to Brooks Station, in Hocking County, where observations were in progress, and partly finished when the field operations were closed October 22.

Special care was given during the season to the marking of the stations—underground, surface, and reference marks being placed at the principal points. Elevations were determined by barometer; hourly barometric observations were taken on several days at Mount Nebo, and curves were plotted to show the daily variations of pressure. The records of observation have been forwarded to the office. The total number of measurements was six hundred and sixty-four.

Geodetic operations in Indiana.—As the result of a reconnaissance made by Prof. J. L. Campbell, Acting Assistant in the Coast and Geodetic Survey, for the extension of the triangulation of the State of Indiana, a practicable scheme was developed, including four quadrilaterals, starting as a base from the line Bangs–Blind Asylum, and stretching northward for about twenty-five miles. Professor Campbell has presented a full report of his reconnaissance, specifying the stations at which high tripods and observing scaffolds must be erected, and those between which lines of sight must be opened. Barometric observations for the approximate determination of heights were taken at all favorable opportunities during the progress of the reconnaissance, the intention being to compare the results obtained by barometer with those given by leveling. The season closed with the month of September. In fixing the location of high points for observing stations, Professor Campbell was led to notice the fact of the general elevation of the swamp lands of the State above the channels of the main water-courses, and deemed it of sufficient importance to be communicated to the State legislature through the governor, Hon. Albert G. Porter. Action looking to the reclamation of these lands was subsequently taken by the State authorities, and during the spring and summer of 1882 Professor Campbell, with my approval, was in charge of works undertaken for this purpose. Upon the completion of that duty, he will resume the charge of geodetic operations in the State.

Reconnaissance for the extension of the primary triangulation eastward in Illinois and Indiana.—In pursuance of instructions to resume the reconnaissance for the extension of the primary triangulation from the eastern boundary of Illinois eastward through Indiana and Ohio along the thirty-ninth parallel, Assistant F. W. Perkins took the field at the opening of the fiscal year, and starting from the line, Hunt City–Claremont, near the eastern boundary of Illinois, as a base of operations, he pushed the reconnaissance until the scheme was extended as far as a line running north through Mitchell, Ind. The season proved exceptionally unfavorable owing to the extreme drought and the resulting smoky condition of the atmosphere. Early in December the work was brought to a close, and the records and sketches were transmitted to the office. The subsequent work of Assistant Perkins on the coast of Texas has been referred to under the heading of Section IX.

Geodesic leveling.—Early in June, 1882, Assistant Andrew Braid began the work of connecting the terminal point of the line of geodesic levels of 1879 at Mitchell, Ind., with a permanent bench-mark of the Mississippi River Commission at or near Saint Louis, Mo. Beginning at Vincennes, Ind., and working eastward, fifty miles had been run at the close of the fiscal year, leaving a distance of sixteen miles to finish the line of levels of precision between Vincennes and Mitchell.

Continuation of the primary triangulation across the State of Illinois.—The primary triangulation across the State of Illinois, forming part of the geodetic connection of the Atlantic and Pacific coast triangulations, was advanced in 1881 by the occupation of three primary stations. Assistant George A. Fairfield, in charge of this work, was at Berger Station, in the vicinity of Lebanon, Saint Clair County, Illinois, at the opening of the fiscal year. Observations were begun July 15 and continued till August 10, when they were completed. Parkinson Station, near Highland, Madison County, was next occupied. Between August 21 and September 28, all observations needed at this station had been obtained, and preparations were immediately made for moving camp to Geoffrey Station, about nineteen miles southeast of Parkinson. During a very violent gale which prevailed upon the night of the arrival of the party, the signal at Geoffrey was blown down. It was at once rebuilt, and observations were begun October 19. Field operations were closed November 6, when the work at Geoffrey was finished.

Assistant Fairfield reports that the weather throughout the season was the most unfavorable that he had ever experienced. It was marked by intense heat and an almost unprecedented drought. In the observing tent at midnight the thermometer was at times 102° Fahr. The air was constantly filled with fine dust taken up from the roads and plowed fields where it was at least six inches deep. Thick black smoke from the soft coal used as fuel on the numerous lines of railroad and in factories and flour-mills, combined with the dust to make an atmosphere through which signals were seldom visible during the day. It was only by the use of student-lamps, fitted with reflectors so as to be effective for night signals, as suggested by Assistant C. O. Boutelle (Appendix No. 8, Report for 1880), that good progress was made in the work. On clear nights, these lamps, showing a bright point of light, were readily seen with the naked eye at stations twenty-six miles distant, though at times when the atmosphere was thick with dust and smoke they were not visible through the telescope at a distance of eighteen miles. All of the observations, except those upon secondary points, such as church spires, etc., were made at night upon the student-lamp reflectors. For future occupation, two tripod and scaffold signals, each seventy-five feet in height, were erected, one at Hoile and the other at Sturgis Station, and an ordinary tripod signal at Bording Station.

Subassistant John B. Weir was attached to the party, and rendered valuable aid throughout the season. At Geoffrey Station he made all of the observations with good results. He ran also a line of levels from Berger Station to the town of Summerfield, Ill., on the Ohio and Mississippi Railroad, establishing there a bench-mark which will ultimately be connected with the transcontinental line of leveling of precision. Statistics of the season's work are as follows:

Primary stations occupied, number of	3
Primary signals observed upon, number of	8
Secondary objects observed upon, number of	18
Observations for horizontal directions, number of	1,686

Assistant Fairfield was engaged during the winter in completing the records and computations of his observations, and was subsequently assigned to duty at the office.

Geodetic operations in Wisconsin.—For the continuation of the triangulation of the State of Wisconsin, Prof. J. E. Davies took the field at the beginning of the fiscal year. His work involved a thorough reconnaissance of the country between Gratiot's Grove and Beloit, near the southern boundary of Wisconsin, with a view to fill up the gap in triangulation mainly to the west and partly to the east of Rock River, and also the occupation of as many of the stations as the length of the working season would permit.

The reconnaissance made by Professor Davies developed two schemes of triangulation, one resting upon the line Fayette–Blue Mounds as a base; the other proceeding towards Beloit from the line Oakland–Union, both of which last-named stations are to the southeastward of Madison.

A re-occupation of Gratiot's Grove had become necessary in order to establish with the requisite accuracy the position of the signal at Sherrill's Mound in Iowa. The location of this signal, on a low hill just across the Mississippi River, and its frequent obscuration by the river fogs, induced Professor Davies to resort to the use of night-signals in the form of student-lamp reflectors as proposed by Assistant C. O. Boutelle. With the observations upon Sherrill's Mound were combined observations upon Platte Mound and Fayette. Full sets of angles were obtained upon the night-signals established at these stations with very satisfactory results. These measurements occupied the month of July. Three more stations, Mount Pleasant, Union, and Magnolia, were occupied during the season which closed with the month of September. Records and computations of the work have been sent to the office. The statistics are:

Number of vertical angles measured	17
Number of repetitions of vertical angles	636
Number of horizontal angles measured	78
Number of repetitions of angles	3,870

Magnetic observations.—It was decided in October, 1881, to bring to a close the magnetic observations at the magnetic observatory in the grounds of the University of Wisconsin. The Brooke differential magnetographs had furnished records of magnetic phenomena since March, 1877, but owing to the difficulty of obtaining longer the necessary photographic, mechanical, and scientific skill in the management of the apparatus without a greatly increased expenditure, the observer temporarily in charge was directed to take down the apparatus and forward it with the portable magnetometer and dip-circle to the office as soon as the usual annual determination could be made of the absolute values of the declination, dip, and intensity.

Mr. Werner Suess was instructed to make the observations for these values, and did so in November, 1881, on his return from the Pacific coast.

SECTION XV.

MISSOURI, KANSAS, IOWA, NEBRASKA, MINNESOTA, AND DAKOTA. (SKETCHES Nos. 23 and 25.)

Telegraphic longitudes.—The determination of the longitude of Saint Louis, Mo., by telegraphic exchanges from Nashville, Tenn., occupied the longitude parties during the month of October, 1881. Their work in Sections III, XIII, and XIV has already been stated under the heads of those sections. For the first series of exchanges, with Assistant G. W. Dean at Saint Louis, and Assistant Edwin Smith at Nashville, observations were made on four nights between October 10 and October 22, and after the change of places of the observers, four more nights were obtained between October 25 and November 1. The latitude of the station at Saint Louis was determined by Mr. F. H. Parsons, aid in Assistant Dean's party, with Transit No. 6.

Preparations had been made before the completion of the last series of exchanges for the occupation of a station at Vincennes, Ind., and the determination of its longitude from Nashville and from Saint Louis. The Saint Louis party moved to Vincennes. Exchanges were had on the nights of November 12, 13, and 14, between Nashville and Vincennes, and again on the nights of November 16, 19, and 24, in the changed position of the observers.

Assistant Dean having been then relieved from duty at his own request, Subassistant C. H. Sinclair was left in charge of the Vincennes Station. The Nashville party moved to Saint Louis, and the determination of the longitude of Vincennes from Saint Louis was made on the nights of November 28, December 7, 8, and 9 with Mr. Smith at Saint Louis and Mr. Sinclair at Vincennes. Similar determinations were made on the nights of December 14, 16, and 23, the observers having changed places, as usual, to eliminate the effect of personal equation.

This completed the determination of the longitude triangle Nashville–Saint Louis–Vincennes, and work for the season was then closed. The latitude of the station at Vincennes had been established by Subassistant Sinclair with Transit No. 4.

During the past two years, special attention has been given to the study of improved forms of instruments and apparatus for the use of the longitude parties. To do away with the necessity of using separate instruments for observing time and latitude, the forty-six and forty-eight inch transits, heretofore used solely for determinations of time, were fitted for latitude observations, as already mentioned. Two new chronographs, by Fauth & Co., with cylinders eleven inches in diameter and about fourteen inches in length, were used. These chronographs were so arranged that the speed of the cylinder could be doubled when required. Their working was in general quite satisfactory, but some excess of friction made itself apparent in very cold weather. This, with other slight defects, detected on a first trial in the field, will doubtless be remedied without difficulty. Experiments made during the previous season had led to the construction of new signal relays, made after the plan of the Farmer relays, with slight modifications, the helices being one and a half inches in length, and the resistance three hundred and fifty ohms. Measurements of the armature and transmission times obtained with these relays, were less than heretofore found in circuits of equal length, and the variation of the separate results from the mean value was so small that the errors in the longitudes due to armature and transmission time are quite insignificant.

For the determination of time, the same stars, selected from the American Ephemeris and the Berlin Catalogue, were observed at the stations between which exchanges were in progress, the stars being arranged in groups, two of which were observed before the exchange of signals and two or more after. The insulation of the wire and the resistance of the line and batteries were tested on each longitude night as soon as the lines became available; signals from the break-circuit chronometers were then recorded upon the chronographs at the respective stations, in order to identify the time of exchange, and to obtain a careful adjustment of the relays; then followed the exchange of about thirty arbitrary signals for longitude. Eight or ten minutes on each night sufficed for the actual occupation of the telegraph line, when it could be had absolutely free from interruption. Original and duplicate records of the season's work have been completed and forwarded to the office; also abstracts of the preliminary reductions.

Assistant Dean makes acknowledgment in his report of the many courtesies shown to the longitude parties by Col. John Van Horne, vice-president and general superintendent of the Western Union Telegraph Company, by Mr. G. W. Trabue, general superintendent at Nashville, Tenn., and by Mr. M. Marean, chief operator and electrician at the Western Union office in Washington. Admiral John Rodgers, Superintendent of the United States Naval Observatory; Prof. Ormond Stone, director of the Cincinnati Observatory; President W. G. Eliot and Prof. H. S. Pritchett of the Washington University, Saint Louis, extended facilities to the officers directing the operations which are heartily acknowledged in their several reports. The acceptable services rendered in the work by Subassistant C. H. Sinclair, and by Messrs. F. H. Parsons and Carlisle Terry, Aids, are specially mentioned.

Reconnaissance for the extension of the primary triangulation in Missouri to the westward.—In accordance with instructions for the prosecution of reconnaissance westward in Missouri, Assistant F. D. Granger organized his party at Sedalia, Mo., at the beginning of the fiscal year. The triangulation had been advanced during previous seasons up to the line Heard–Schnackenberg, which formed also the western limit of the reconnaissance. Heard Station, near Sedalia, in Pettis County, had been occupied, and Schnackenberg, near the town of Cole Camp, Benton County, about fifteen miles in a southeastwardly direction, had been observed upon. Making this line his base of operations, Mr. Granger made a general examination of the country to the westward as far as the Kansas and Missouri State line. The whole country gone over was in its general character rolling, interspersed with broken ground—about one-fifth of its entire area wooded—and the open portion principally farm lands divided often by high hedges of Osage orange, and veined with the beds of small streams which were mostly dry, except during the rainy season.

Keeping steadily in view the extension of the triangulation by a system of quadrilaterals or of hexagonal figures, with sides of not less than fifteen miles in length, and which, starting north of the parallel of 38° 30′, and in longitude 93° 15′ (nearly), should reach the parallel of 39° in longitude 95°, Mr. Granger continued his reconnaissance until the close of October, when he was enabled to present a satisfactory scheme, reaching through seventeen stations to Blue Mound, near Lawrence, Kans., a distance of upwards of one hundred miles westward of Sedalia. Mr. Isaac Winston served as Aid in the party. His energy and efficiency are acknowledged by his chief as contributing largely to the success of the work. Mr. C. H. Zoll rendered acceptable service as recorder.

SECTION XVI.

NEVADA, UTAH, COLORADO, ARIZONA, AND NEW MEXICO. (SKETCH No. 24.)

Primary triangulation in Nevada.—The extension to the eastward of the transcontinental primary triangulation, by the occupation of stations in Nevada, was placed in charge of Assistant William Eimbeck. At the beginning of the fiscal year his party was established in camp upon Mount Callahan, one of the peaks of the Sierra Nevada, having an elevation of upwards of ten thousand two hundred feet. Between June 28 and August 3, 1881, observations of horizontal directions and vertical angles were obtained upon five primary stations, and a number of secondary points. Observations were also made for time, latitude, azimuth, and the magnetic elements. A bench-mark was established on the Nevada Central Railroad, at a distance of about ten miles from the station. This bench-mark was connected with the triangulation, and the difference of elevation between it and the station was determined by observations of vertical angles. This bench-mark and others similarly fixed in position will be available as stations in lines of level of precision, and their reference in elevation to the mountain peaks will greatly facilitate the exact determination of heights. High winds were an obstacle to progress, not unfrequently, at Mount Callahan, one of the severest gales lasting five days and nights.

Upon the completion of this station, early in August, preparations were begun for the occupation of Eureka, a peak nearly ten thousand seven hundred feet in height. By the 25th of August the instruments were mounted and in readiness for beginning observations. These were made at every favorable opportunity, but not without much interruption from the unusually cold and boisterous weather. Horizontal directions were observed upon five primary stations, and upon many secondary objects in twenty positions of the theodolite; double zenith distances were observed upon all primary and many secondary points; observations for azimuth upon Polaris were made with the theodolite in twenty-five positions; for latitude twenty-two pairs of stars were observed for five nights. The magnetic declination, dip, and intensity were determined by observations on four days. On the 23d of September occurred the first snow-storm of the season, and the temperature fell to 16° Fahr.

The occupation of Eureka was completed on the 5th of October. Teams with freight and pack animals were at once started for the base of the White Pine Range, the next station being White Pine, a peak over eleven thousand three hundred feet in height, and very abrupt, ragged, and rocky. A three days' snow-storm, which prevailed while preparations for the occupation were in progress, caused some delay, but by the first of November everything was in readiness for work. Observations of horizontal directions, double zenith distances, and for magnetic declination, dip, and intensity were made until the middle of December, when the station was finished, and field operations closed. Mr. R. A. Marr served as Aid in the party. Early in the winter Assistant Eimbeck was directed to report for office duty, and before returning to the field had completed the records and results of his season's work.

Primary triangulation in Colorado.—At the opening of the fiscal year the primary triangulation in Colorado had been extended eastward along or near the thirty-ninth parallel to the line Hugo–Adobe. Station Hugo, in Elbert County, had been occupied during the previous season by Assistant O. H. Tittmann, and upon resuming charge of the work in June, 1881, he proceeded to organize his party for the occupation of station Adobe, in Bent County, about twenty-seven miles to the southward of Hugo. After the erection of a tripod for elevating the theodolite, measurements of horizontal angles were begun about the 20th of July. Five stations were observed upon, and the azimuth of the lines of direction determined. For latitude, observations were made with zenith telescope No. 4. Work at this station was completed on August 17.

Owing to detention by rains, which rendered the prairies impassable for wagons, several days were occupied in transferring the party to a suitable camping ground at the next station, Arroya, near a railway station of that name, on the Kansas Pacific Railroad. Four miles southwest of this, the trigonometric point was established on a high sandy ridge, dividing the waters of Rush Creek from those of the Big Sandy. Before beginning observations at Arroya, it was necessary to construct and erect signals at the two primary stations, Kit Carson and Eureka, the locations of which had been determined in a previous reconnaissance. Horizontal angles were observed upon five stations, and on the completion of the work, September 5, station Overland, about sixteen miles north of Arroya, was occupied. Here, in addition to the observations of horizontal angles, an azimuth was determined which gave a very satisfactory agreement with the azimuth observed at East Base, as carried forward by computation.

On September 26 the party moved to Eureka Station, in San Juan County. From this station the reconnaissance was extended eastward for the selection of two primary stations. These were named Landsman and First View, and were included in the observations made from Eureka. The work at this station, and at the next one, Kit Carson, in Bent County, occupied the party till the last of October, when field operations closed. Measurements of vertical angles were made at all of the stations during the season, and secondary points determined whenever practicable.

By the kind permission of Lieutenant Reed, U. S. A., commanding officer at Fort Wallace, the instruments and camp equipage were stored at that post. Messrs. J. E. McGrath and G. F. Bird served acceptably as Aids in the party, and Mr. James L. Harper as recorder. Upon the completion of his field-work, Assistant Tittmann, in compliance with instructions, reported for duty at the office.

SECTION XVII.

IDAHO, WYOMING, AND MONTANA TERRITORIES.

***Magnetic observations.*—The magnetic tour of Assistant J. S. Lawson, which has already been referred to under the heading of Section XI, included in its plan the occupation of certain stations in the Territory of Idaho. Steamboat Landing or Pend d'Oreille, a station at the south end of Lake Pend d'Oreille; Siniaquotem, near the northern end of the lake, and Lewiston were occupied**

for the determination of the magnetic declination, dip, and intensity in September, 1881. The usual observations for azimuth and for geographical position of stations were made. For the study of the secular change of the magnetic variation, Siniaquotem was an important point, observations having been made there in 1859 by Captain Haig, of the British army, then on duty with the Boundary Commission.

Verification of the northern boundary of Wyoming Territory.—Towards the end of August, 1881, in compliance with a request from the Secretary of the Interior, addressed to the Secretary of the Treasury, asking the detail of an officer of the Coast and Geodetic Survey, for the purpose of making an examination in the field, of the northern boundary of Wyoming Territory, as surveyed and marked under contract with the Interior Department in 1878, telegraphic orders were sent to Assistant B. A. Colonna, then on duty on the Pacific coast, to report for service at a point near the locality of the work.

Inquiry into the details of the proposed verification having led me to a belief that a critical examination by experts named by the Interior Department, would lead to a more precise definition of those portions of the line needing verification, a Commission was appointed upon my recommendation, to take cognizance of all papers relating to the survey of the boundary line, and, pending the deliberations of the Commission, and until their report could be prepared, the actual verification in the field was suspended.

The members of the Commission appointed by the Secretary of the Interior were the Superintendent of the Coast and Geodetic Survey, and Messrs. Henry Gannett and John D. Hoffman, of the Interior Department. Under special instructions from the Superintendent, Assistant Colonna was ordered to report at the office as secretary to the Commission. Having in this capacity familiarized himself with the records and field-notes of the survey, and with the conclusions arrived at by the Commission, as embodied in their report to the Secretary of the Interior, Mr. Colonna was directed May 1, 1881, to be on the ground as soon as practicable with the necessary instruments and equipment. He reached Fort Meade, in Dakota Territory, towards the close of May. In pursuance of orders from the War Department, the officer commanding that post, Maj. Edward Ball, U. S. A., assigned to him as escort a troop of the Seventh Cavalry, under command of Capt. F. M. Gibson. On the 6th of June he arrived at the northeast corner of Wyoming Territory, determined the latitude of his station, established an azimuth, and began the work of verification as directed by the Commission, carrying it westward along the forty-fifth parallel, with which the boundary line was intended to conform. At the end of the year for which this report is made out, the work was making good progress, Assistant Colonna having reached the three hundred and twentieth mile-post. Mr. T. P. Borden rendered acceptable service as Aid in the party.

COAST AND GEODETIC SURVEY OFFICE.

During the year there were several changes in the *personnel* of the office. At the opening of the year I was, as for many years previous, Assistant in charge of Office and Topography. Upon the death of the late Superintendent, to which event full reference has been made, I was appointed by the Secretary of the Treasury as Assistant in charge of the Coast and Geodetic Survey, pending the appointment of a successor to Mr. Patterson. For several months I filled the double position of Assistant in charge of the Survey and Assistant in charge of Office and Topography, being aided in the duties of the latter position by Assistant Edward Goodfellow, who for several years past had been my immediate assistant in the execution of office details, and to whose experience and judgment I am much indebted for the lightening of the labors of the double duty devolving upon me.

Upon the return of Assistant Richard D. Cutts from duty in the field, he was assigned temporarily, on November 4, to the position of Assistant in charge of Office and Topography, and upon my own appointment, December 23, as Superintendent, Assistant Cutts assumed the permanent charge of the duties appertaining to that position.

Assistant Edward Goodfellow continued to aid in the executive details and the official correspondence of the office from July 1 to April 4, 1882, at which date he was relieved by Subassistant

H. W. Blair, who discharged during the remainder of the fiscal year the duties of the position to the entire satisfaction of the Assistant in charge and with credit to himself. The clerical duties were, as heretofore, ably performed by Mr. Wm. B. French.

During the year Prof. Wm. Ferrel continued his investigations of meteorological and tidal phenomena, and prepared the third part of his "Meteorological Researches," the paper being devoted to barometric hypsometry and reduction of the barometer to sea-level. This paper has been published as Appendix No. 10 to my Report for 1881. Mr. Ferrel also devised a tide-predicting machine, which has been constructed under his general supervision by Fauth & Co., of Washington, D. C. The working drawings were prepared and mechanical details arranged by Mr. Saegmuller, the chief mechanician, to whose mechanical ingenuity the successful completion of the work is very largely due.

Further improvements have been made in the circular dividing machine. Mr. Saegmuller has made an elaborate redetermination of its errors of graduation. A new automatic cleaner and stop have been added; also a new turbine wheel to replace the old one, which had become much worn. By the use of the reservoir mentioned in the last annual Report, a constant head and consequent uniform power is maintained for driving the machine.

The Drawing and Engraving Divisions have been pushed to their utmost capacity in the endeavor to supply the increased demand for the results of the surveys. This demand has also prompted the issuing of a relatively large number of charts by the photolithographic method. The total distribution of charts for the year was twenty-nine thousand and forty-nine copies, an increase of five thousand three hundred and thirty-four copies over the preceding year.

During the year the following field officers were on duty at the office for the times stated:

Assistant George A. Fairfield reported in the early part of March and for the remainder of the year was engaged in assisting the Superintendent in official correspondence, and in compiling statistics of average cloudiness in the United States.

Assistant W. H. Dennis reported on January 6, and was engaged in inking a topographical sheet of the eastern part of Long Island and one of Blue Hill Bay, Me.; making a copy of topographical survey of Cape Disappointment; inking sheet of Narraguagas Valley, from Millbridge to Cherryville, Me., and also the sheets of his last season's topographical work. On June 19 he was detached from office duty and was occupied during the remainder of the month in making preparations for resumption of field-work.

Assistant Charles Hosmer reported at the office January 2. From that date until February 20, he was engaged in topographical drawing and inking of topographical sheets. On February 21 he was detached from office duty, and took the field temporarily for the determination of the new positions of light ships and buoys in the approaches to New York Harbor. He returned to the office March 2, and until the close of the fiscal year was engaged in inking his plane-table sheets of the preceding season's work, in inking other sheets, and in miscellaneous topographical drawing.

Assistant A. T. Mosman reported at the office in the middle of March. During the remainder of the month and during part of April he was engaged in topographical drawing. Afterwards he took charge of the rearranging of the library and cataloguing of the books. In May he returned to his home.

Assistant O. H. Tittmann reported at the office early in January. After finishing the computations of his last season's work, duplicating the records, and plotting the triangulation, he was engaged, under the immediate direction of the Superintendent, in correspondence and in computations relative to weights and measures and in collecting and editing materials for the weights and measures report. On June 1 he was relieved from office duty.

Assistant William Eimbeck reported at the office in the middle of March. He was occupied in making the computations of his field-work in Nevada, and of the astronomical observations made during the last season, in revising, finishing, and duplicating his records and plotting the scheme of triangulation in Nevada and Utah. In June he made the annual magnetic observations at the Coast and Geodetic Survey magnetic observatory on Capitol Hill, and also instructed the magnetic observer for the Point Barrow relief party, in the use of instruments and in the computations.

Assistant Edwin Smith reported at the office early in February; was engaged in computing the results of his last season's telegraphic longitude work; in testing a number of levels; in examining various longitude instruments, and attending to alterations and improvements in them, and in continuing the rearrangement of the library and the cataloguing of the books. In the latter part of March he was relieved from office duty and was occupied upon pendulum experiments and observations for the remainder of the fiscal year.

Assistant Andrew Braid reported at the office in the early part of May. During the balance of the month he was employed in computing the results of the triangulation and heights of stations in New York and Vermont, in 1881. On June 1 he took the field for the continuation of the transcontinental levels of precision.

Subassistant H. W. Blair reported at the office on January 20, and was occupied, under the immediate direction of the Superintendent, in comparing a set of ordnance gauges for the Frankford Arsenal, Philadelphia; in an examination and determination of periodic inequalities in micrometer screw of zenith telescope No. 2; comparing twelve thermometers and determining corrections; in correspondence and personal conference with a number of firms in Philadelphia, New York, and Providence, in relation to furnishing certain weights and measures for agricultural colleges in the various States; in collecting, collating, and editing data for the weights and measures report. On April 6 Mr. Blair relieved Mr. Goodfellow as immediate Assistant to the Assistant in charge, and continued in this position to the close of the fiscal year, aiding in the office correspondence and executive details with promptness and efficiency.

Subassistant D. B. Wainwright reported at the office on January 9 and was assigned to duty in the Computing Division. From February 20 to March 2 he was detached to assist in the determination of the new position of light ships and buoys in the approaches to New York Harbor. On his return he was again assigned to duty in the Computing Division, and was so occupied until June 6, when he took the field for the topographical survey of the District of Columbia.

Subassistant C. H. Sinclair reported at the office early in February. He was engaged during February in an examination of the limb and determination of the eccentricity of 10-inch theodolite No. 82 and of 20-inch theodolite No. 115. For the remainder of the fiscal year he was occupied in preparing an "Index of scientific papers published by the Coast Survey from 1845 to 1880," being a greatly enlarged edition of Appendix No. 17 of Report of 1871. The new index appears as Appendix No. 6 of the Report for 1881.

Mr. F. H. Parsons, Aid, reported at the office on January 2. For a short while he was on special duty under direction of the Superintendent. On January 9 he was assigned to duty with the Hydrographic Inspector, and assisted in the official correspondence and executive details of that office until June 26, when he took the field in charge of an adjunct party for the determination of the longitude of Charlottesville, Va.

Mr. Robert A. Marr, Aid, reported at the office in the early part of April. He assisted Mr. Eimbeck in the computations of his last season's work, duplicated some of the records, and computed the astronomical latitudes of Mount Callahan and Eureka Stations, Nevada.

Mr. Isaac Winston, Aid, reported at the office on December 3, and was assigned to duty in the Computing Division. On December 29 he was detached and sent on topographic work on the coast of Texas. He again reported at the office on May 11, and was on duty in the Computing Division up to the close of the fiscal year.

Mr. J. E. McGrath, Aid, reported at the office on January 20, and was on duty in the Computing Division until March 8, when he was detached for topographic work on the coast of Texas.

Mr. T. P. Borden, Aid, reported on November 17, and was on duty in the Computing Division until December 12, when he was temporarily detached, reporting again on January 23 and again assigned to the Computing Divison. On May 1 he reported to Assistant Colonna, for duty on the work of verification of the survey of the northern boundary of Wyoming.

Mr. W. B. Fairfield, extra observer, reported at the office on January 25, and was on duty in the Computing Division until June 6, when he was relieved and reported to Assistant Mosman for duty in the triangulation of Delaware River and Bay.

Mr. J. B. Boutelle, extra observer, reported at the office in November, and was assigned to duty in the Drawing Division, where he served until ordered to field-work in January.

Computing Division.—As heretofore, this division was under the charge of Assistant Schott, In August Mr. Schott went to California to take part in the measurement of the Yolo Base with the five-meter compensating base bars that had been constructed during the previous year under his direction and according to his plans. During his absence, Mr. E. H. Courtenay was in temporary charge of the Computing Division. Mr. Schott returned to Washington in October. In addition to the labor of supervising the office computation of all geodetic, magnetic, and astronomical work done on the Survey, Mr. Schott made the comparisons and computations for a redetermination of the length of the five-meter standard No. 2, and determined the length and coefficient of expansion of a meter-bar belonging to the United States Signal Service. He also prepared a revised and enlarged edition (the third) of his pamphlet on the determination of time, latitude, and azimuth. This is printed as Appendix No. 14 to the Report of 1880. A third edition of his paper on the measurement of terrestrial magnetism was also prepared, and is printed as Appendix No. 8 to the Report of 1881. In addition to these papers he has made a "collection of magnetic results," comprising all results obtained by the Coast and Geodetic Survey from 1833 to July, 1882, at more than six hundred stations, giving the magnetic elements, and, where possible the descriptions of stations. These results, together with all other available data within the United States, are published as Appendix No. 9 to the Report of 1881.

On February 20 the division lost the valuable services of Dr. Gottlieb Rumpf, who died after an illness of four weeks. Dr. Rumpf had been uninterruptedly connected with the Computing Division since April, 1849. In his annual report, which is appended, Mr. Schott makes a proper and deserved notice of the fidelity and ability of the deceased.

Statements of the force employed in the Computing Division and of the work executed by the regular and temporary members of the division will be found in full in the annual report of the Computing Division, Appendix No. 6.

Hydrographic Division.—During the year this division was in charge of Commander C. M. Chester, U. S. N. At the beginning of the year Lieut. C. T. Hutchins, U. S. N., was acting as assistant to the hydrographic inspector. He was, however, detached in July, 1881, and was succeeded by Lieut. Richardson Clover, U. S. N., who continued in the position to the close of the fiscal year. The services of the naval officers attached to the Survey have been referred to in the summary of work in the various sections. The office work under the general direction of Commander Chester and the immediate supervision of Lieutenant Clover, may be summarized as follows:

Mr. E. Willenbucher, hydrographic draughtsman, protracted, plotted, or drew twenty hydrographic sheets, four of which were of the Texas coast, off Padre Island, nine of the Mississippi River, two off west coast of Florida, two of the Delaware River, one of the entrance to New York Harbor, one off Rockaway Inlet, and one of Dyer's Bay, Me. He also verified the reductions on nine charts, made numerous tracings in response to special calls, and made projections for hydrographic parties.

Mr. W. C. Willenbucher, hydrographic draughtsman, was on field duty with Assistant G. Bradford during the month of July, 1881. During the remainder of the year he was on duty in the office of the Hydrographic Inspector. He protracted, plotted, or drew nineteen hydrographic sheets, of which five were off the coast of Maine, two off the coast of Massachusetts, three of the Delaware River, one in Long Island Sound, one of Chincoteague Shoals, Va., two of the Elizabeth River, Va., and five off the Florida coast. He made, also, eleven tracings of hydrographic sheets, corrected Aids to Navigation of numerous charts, made reductions of additional hydrography on former sheets, verified several coast and harbor charts, and brought up progress sketches and attended to various minor details of office work.

Mr. F. C. Donn, hydrographic draughtsman, was temporarily detached at the beginning of the fiscal year for duty on the topographical survey of the site for the new Naval Observatory. He was reassigned on the 1st of August, and during that month was in the field on hydrographic duty. For the remainder of the fiscal year he was on office duty. He protracted, plotted, inked, or drew, fourteen hydrographic sheets, of which one was of a portion of the Delaware River, five off the Florida coast, six off the Pacific coast of the United States, and two off the coast of Alaska. In addition to these he made tracings from, reduced, or made projections for, twenty-four other original sheets. The full report of the hydrographic inspector appears in Appendix No. 6.

Drawing Division.—This division has continued under the charge of Mr. W. T. Bright. In it all original topographic sheets are examined; reductions made from them for the preparation of plates for engraved charts; drawings made for such charts as are to be published by photolithographic process; progress sketches for the annual reports prepared or brought up to date; drawings made for engraving or photolithographing illustrations to special papers in the annual reports; projections furnished to field parties for topographic or hydrographic work; tracings made from original sheets, and information furnished in response to special calls.

During the year there has been a marked increase in the number of first-class charts produced by the photolithographic process. In this way the office has been enabled to prepare for publication, and to issue to the public, the information obtained from combined original field-notes and sheets, without the delay attendant upon the preparation of engraved plates. Charts prepared by this method, while embodying the correct results of the latest surveys, are but transient in nature, and intended only to supply the urgent demand for information relating to the particular locality. An edition of these, sufficient to meet all probable calls, is printed for use during the time that the engraved plates are in course of preparation.

The report from the Drawing Division, which appears in Appendix No. 6, shows the force employed and the special character of work done by each member of the division.

Appendix No. 4 gives a list of the charts, sketches, and illustrations that were completed or in progress during the year, and also a detailed statement of the work executed by each draughtsman.

A statement of the information furnished from the division to meet special requests during the year is embodied in Appendix No. 3.

Engraving Division.—During the past year this division was under the charge of Assistant H. G. Ogden. In addition to the work done upon plates of charts, there were made a number of plates of illustrations for the Coast Pilot, and for sketches and illustrations for the Annual Report of the Superintendent. The report shows a total of two hundred and forty-four plates upon which work was done. Plates of twenty-eight charts and twenty-three sketches and illustrations were completed. Four charts and twenty-one sketches and illustrations were commenced. One hundred and thirty-two charts and twelve sketches received additions and corrections. At the close of the fiscal year there were on hand thirty-nine plates of charts, and nineteen of sketches and illustrations, upon which work was progressing.

Much additional work in correcting plates, has been entailed by the many changes in the positions of buoys and light-ships in the First and Third Light-House Districts. By an arrangement between the Hydrographic Inspector and the Light-House Board, the Aids to Navigation are corrected by the inspectors of the light-house districts, whereby all changes are promptly reported, and the accuracy and value of the charts greatly increased.

A detailed statement of the force employed in the division will be found in Appendix No. 6, and in Appendix No. 5 is given a statement of the work executed by the engravers.

At the beginning of the fiscal year the control of the printing-office was transferred to the Engraving Division. Two presses are constantly in use, one in charge of Mr. F. Moore, the foreman of the room, the other in charge of Mr. D. N. Hoover. The report shows a total of forty-two thousand one hundred and nine impressions taken during the year.

Division of Topography.—This division was organized at the beginning of the fiscal year and placed in charge of Assistant E. Hergesheimer. The special object of its organization was to secure greater uniformity in inking the topographical sheets, by having the work done under one person of judgment and experience, than is possible where each sheet is inked by the topographer executing the survey. The report of the division (Appendix No. 6) shows thirteen original sheets inked and the reproduction of two sheets nearly worn out. Also the preparation for photolithographing of seven reductions from topographic or hydrographic sheets.

Tidal Division.—Mr. R. S. Avery has continued in charge of this division. He makes examination of all tidal observations and tidal rolls sent in to the office, and directs the computations of the tide tables containing the predictions for the principal ports of the United States: prepares replies to inquiries from officers of the Survey, or others, relative to tidal matters; compiles statistics relative to tides, and conducts the official correspondence with some of the permanent tidal observers.

The tide tables for the Atlantic and for the Pacific coast for 1883 have been computed and published, and the computation of those for 1884 is progressing.

Self-registering gauges have been in operation at six stations. The following table gives a list of the observations made with them which were received at the office during the fiscal year.

Section.	Name of station.	Name of observer.	Permanent or Temporary.	Time of occupation. From—	To—	Number of days.
I	North Haven, Me	J. G. Spaulding	Permanent	April 26, 1881	April 24, 1882	363
I	Providence, R. I	S. M. Gray	Temporary			
II	Sandy Hook, N. J	J. W. Banford	Permanent	June 1, 1881	June 1, 1882	365
X	Saucelito, Cal	E. Gray	do	June 1, 1881	June 1, 1882	365
XII	Kadiak, Alaska	W. J. Fisher	do	March 1, 1881	November 1, 1881	245
	Honolulu, S. I	W. D. Alexander	Temporary	December 3, 1880	December 28, 1881	390

A detailed statement of the work done by each computer is given in the report, Appendix No. 6.

Archives.—The archives have continued in care of Mr. G. A. Stewart. The following list shows the number of volumes of records and cahïers of computation, topographic and hydrographic sheets, etc., received and registered during the fiscal year:

Triangulation, original, number of volumes	275
Astronomical observations, original, number of volumes	74
Magnetic observations, original, number of volumes	66
Duplicates of the above, number of volumes	331
Cahïers of computations	142
Soundings and angles, originals, number of volumes	242
Soundings and angles, duplicates, number of volumes	168
Tidal and current observations, originals, number of volumes	64
Tidal and current observations, duplicates, number of volumes	51
Specimens of bottom, number of	504
Topographical sheets, originals	14
Hydrographical sheets, originals	42

Mr. Stewart has prepared a "list of original topographic sheets, geographically arranged, registered in the archives of the United States Coast and Geodetic Survey from 1834 to June 30, 1882," and also a similar list of hydrographic sheets.

Electrotyping and Photographing Division.—The work in this division has been executed by Dr. A. Zumbrock, aided by Frank Over. The report shows the following work done:

Electrotypes:

For the Survey: Twenty-eight altos, weighing five hundred and eight pounds; twelve bassos, weighing three hundred and fifty-four pounds.

For the Engineer Corps: Eight altos, weighing one hundred and seventy pounds; seven bassos, weighing two hundred and thirty-five pounds.

For the Hydrographic Office: Six altos, weighing one hundred and fifty-one pounds; five bassos, weighing two hundred and sixty-two pounds.

Total, sixty-six plates, weighing one thousand six hundred and eighty pounds, and having a plate surface of sixty-nine thousand and six square inches.

Besides the electrotyping, there were forty-nine plates steel faced, forty-six negatives were taken of instruments or drawings, and one hundred and eighty-two prints were made.

Division of Instruments and Repairs.—Mr. G. N. Saegmuller, chief mechanician, has continued in charge of the instrument shops. The improvements made in the circular dividing machine have been already mentioned. In addition to the repairs constantly required for the field instruments, there was made in the instrument room a vertical comparator for comparing yard and meter pendulums; four of the forty-six-inch transits were adapted for latitude work by the addition of larger circles, delicate levels, and micrometer eye-pieces; comparisons were made of several sets of the secondary base bars, a special apparatus having been constructed for the more ready execution of such work, and experiments were made in "dark field illumination" for theodolite telescopes for observing night-signals. The force employed, with the character of work performed, is stated in the report of the chief mechanician, Appendix No. 6.

Miscellaneous Division.—Mr. M. W. Wines has continued in charge of this division. The duties of the position comprise the correspondence with sale agents relating to the supply and sale of charts, Coast Pilots, and Tide Tables; the purchase, custody, and issue of stationery; the printing and issue of the blank forms, record books, etc., used in the office or in field-work, and of the annual reports and other publications of the Survey; the supervision and care of the office buildings and furniture; the general direction of work in the carpenter shop, and such other special duties as have been assigned from time to time by the Superintendent or the Assistant in charge of Office.

Due distribution of the various publications of the Survey was made to the Departments of Government. The agencies for the sale of publications have been regularly supplied with charts, Coast Pilots, and Tide Tables. The Appendices to the Annual Reports, of which extra copies have been published in pamphlet form for free distribution, were furnished to all proper applicants, and the usual wide circulation was given to the Notices to Mariners.

During the year there were received from the Public Printer the following numbers of the publications named, viz:

	Copies.
Tide Tables for Atlantic Coast for 1882	2,000
Tide Tables for Atlantic Coast for 1883	2,500
Tide Tables for Pacific Coast for 1882	1,500
Tide Tables for Pacific Coast for 1883	2,000
Atlantic Coast Pilot, Division B: Boston to New York (second edition)	531
Atlantic Local Coast Pilot, Subdivision 14: New York to Delaware Entrance (first edition)	494
Atlantic Local Coast Pilot, Subdivision 3: Penobscot Bay and Tributaries (third edition)	300
Supplement to Deep-Sea Sounding and Dredging	500
Notice to Mariners, No. 32: New shoal, Frying Pan Shoals, off Cape Fear, N. C.	500
Notice to Mariners, No. 33: Development of Fiske Rock, Narragansett Bay, R. I.	1,000
Laws of general application for the use of the United States Coast and Geodetic Survey	500
Annual Report of the Superintendent for 1878	683
Appendices to the Report for 1879:	
No. 7. Description of a new meridian instrument	250
No. 8. Local deflections of the plumb line at stations of the oblique arc along and near our Atlantic coast	500
No. 9. Secular change of magnetic declination in the United States and at some foreign stations (fourth edition)	500
No. 10. Physical hydrography of the Gulf of Maine	500
No. 11. Report on the preparation of standard topographical drawings	200
No. 14. On the internal constitution of the earth	100
Nos. 15 and 16 (bound together). Instruments used for precise leveling	500
Appendices to the Report for 1880:	
No. 6. Report on telegraphic longitudes	500
No. 7. Explanation of apparatus for observation of telegraphic longitudes	250
No. 8. Report on geodetic night signals	300

No. 10. Comparison of surveys on Mississippi River, vicinity of Cubitt's Gap	300
No. 11. Report on geodesic leveling on the Mississippi River	300
No. 12. Report on the blue clay of the Mississippi River	300
No. 16. The currents and temperatures of Bering Sea	300

There were distributed during the year twelve hundred and fifty copies of the annual reports and eight hundred and fifty-five divisions of the Coast Pilot, including subdivisions.

There were received in the chart-room during the year thirty thousand and forty-two sheets of charts, of which twenty-four thousand one hundred and eighty-three were copper-plate impressions and five thousand eight hundred and fifty-nine were printed from stone.

The issue of these charts was made under the immediate supervision of Mr. Thomas McDonnell until within a short time previous to his death, which occurred on the 29th of May, 1882, since which time Mr. Hugo Eichholtz has been in charge of the chart-room. The total distribution of charts during the year was twenty-nine thousand and forty-nine copies, being an increase of five thousand three hundred and thirty-four copies over the preceding year.

The carpenter work of the office, including the wood-work of instruments and their packing-boxes, was done by Mr. A. Yeatman, assisted by G. W. Clarvoe and G. F. Fox.

The duties of janitor of the building were performed by Mr. N. Y. Cavitt.

In the office of the assistant in charge the clerical duties were performed by Messrs. W. B. French and R. M. Harvey.

On the 10th of January the resignation of Dr. J. W. Porter as Disbursing Agent of the Survey took effect, and his successor, W. B. Morgan, esq., entered upon the duties of that position.

In the preparation of this report I have been aided by Assistant Edward Goodfellow. Mr. W. B. Chilton has continued to act as clerk to the Superintendent, and Mr. C. D. Gedney as stenographer.

Respectfully submitted.

J. E. HILGARD,
Superintendent.

Hon. C. J. FOLGER,
Secretary of the Treasury.

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PART III.

APPENDICES.

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APPENDIX No. 1.

Distribution of surveying parties upon the Atlantic, Gulf of Mexico, and Pacific coasts and the interior of the United States during the fiscal year 1881–'82.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION I.				
Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island, including coast and seaports, bays and rivers.	No. 1	Topography	C. H. Boyd, assistant; Bion Bradbury, jr., extra observer.	Topography (and supplementary triangulation) of Pleasant Bay and River, Me. (See also Section VI.)
	2	Topography	W. H. Dennis, assistant; E. L. Taney, aid.	Topography of the shores of Harrington River, Flat Bay, Back Bay, and adjacent islands.
	3	Topography	Charles Hosmer, assistant	Topography of the shores of Narraguagus River, Pigeon Hill, and Narraguagus Bays, and adjacent islands. (See also Section II.)
	4	Topography	A. W. Longfellow, assistant	Topography of the shores of the Narraguagus River.
	5	Hydrography	Lieut. H. G. O. Colby, U. S. N., assistant; Lieut. H. T. Monahon, U. S. N.; Master W. H. Nostrand, U. S. N.; Ensigns David Daniels, H. T. Mayo, and O. G. Dodge, U. S. N.	Hydrographic survey of Gouldsborough Bay and of Dyer's Bay, Me. Soundings in Kennebeck River and Booth Bay, Me.; also in Rockland Harbor and Muscle Ridge Channel, Me.
	6	Tidal observations	J. G. Spaulding	Series of tidal observations with self-registering tide-gauge continued, and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay.
	7	Hydrography	Lieut. H. G. O. Colby, U. S. N., assistant; Lieut. H. T. Monahon, U. S. N.; Master W. H. Nostrand, U. S. N.; Ensigns David Daniels, H. T. Mayo, and O. G. Dodge, U. S. N.	Examination of dangers in the vicinity of the harbors of Gloucester and Salem, Mass.
	8	Hydrography	J. S. Bradford	Examination for Coast Pilot, of changes off Pollock Rip, caused by change of position of light-ship, and of reported formation of a shoal in that vicinity. (See also Sections II and III.)
	9	Force of gravity ..	Charles S. Peirce, assistant; Henry Farquhar, E. D. Preston.	Absolute determinations of gravity by pendulum experiments at Cambridge, Mass. (See also Section III.)
	10	Geodetic	Prof. E. T. Quimby, acting assistant.	Stations at Mount Washington and Trask Hill occupied for determining points in the triangulation of New Hampshire.
	11	Geodetic	Prof. V. G. Barbour, acting assistant.	Occupation of stations for determining points in the triangulation of Vermont.
	12	Triangulation	Richard D. Cutts, assistant	Primary triangulation for the connection of Lake Champlain with the survey of the coast. Stations occupied in Vermont and in New York. (See also Section II.)
	13	Tidal observations		Observations continued at Providence, R. I., with a self-registering tide-gauge loaned to the city engineer.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION II.				
Connecticut, New York, New Jersey, Pennsylvania, and Delaware, including coast, bays, and rivers.	No. 1	Special hydrography.	Gershom Bradford, assistant......	Determinations of buoys, location of oyster-beds, etc., for the shell-fish commission of the State of Connecticut. Examination of rock off Montauk Point. (See also Section III.)
	2	Hydrography.....	Lieut. E. B. Thomas, U. S. N., assistant; Lieut. J. A. H. Nickels, U. S. N.; Masters J. C. Frémont, C. J. Badger, F. A. Wilner, and H. F. Reich, U. S. N.; Ensign E. M. Katz, U. S. N.	Hydrographic resurvey of part of New York lower bay, between Sandy Hook and Coney Island. (See also Sections III and VI.)
	3	Hydrography.....	J. S. Bradford, assistant...........	Examination of buoys in channels of New York entrance in order to verify their positions for the use of the Coast Pilot. (See also Section III.)
	4	Tidal observations	J. W. Banford....................	Observations continued with the self-registering tide-gauge at Sandy Hook, N. J.
	5	Special triangulation.	Charles Hosmer, assistant; D. B. Wainwright, subassistant.	Determination of position of light-ships off entrance to New York Harbor. (See also Section I.)
	6	Topography and triangulation.	H. L. Whiting, assistant; W. I. Vinal, subassistant; C. H. Van Orden, aid.	Topography of the west shore of the Hudson River from Haverstraw northward. Determination of points by triangulation for the topographical survey.
	7	Special operations	F. H. Gerdes, assistant	Re-marking of stations of the old triangulation of the Hudson River.
	8	Triangulation	Richard D. Cutts, assistant........	Primary triangulation stations occupied in New York for the connection of the survey of Lake Champlain with that of the Atlantic coast. (See also Section I.)
	9	Reconnaissance and triangulation.	Charles O. Boutelle, assistant; J. B. Boutelle, extra observer; T. P. Borden, aid.	Reconnaissance and primary triangulation across the northern part of the State of New York for connecting the triangulation of the Hudson River and Lake Champlain with that of Lake Ontario.
	10	Geodesic leveling.	Andrew Braid, assistant	Line of geodesic leveling carried from Sandy Hook by way of Long Branch and Perth Amboy, N. J., to Easton, Pa.; thence by way of Reading, Harrisburg, and Chambersburg, Pa., to Hagerstown, Md. (See also Sections III and XIV.)
	11	Geodetic..........	Prof. E. A. Bowser, acting assistant.	Reconnaissance and triangulation in the northern part of New Jersey.
	12	Topography and triangulation.	Charles M. Bache, assistant; W. I. Vinal, subassistant.	Topography of the coast of New Jersey continued from vicinity of Hereford Inlet northward. Points for topographic survey determined by triangulation. (See also Section III.)
	13	Hydrography.....	J. S. Bradford, assistant	Examination of reported changes in Delaware and Chesapeake Bays, and verification of data for the Coast Pilot. (See also Sections I and III.)
	14	Hydrography.....	Lieut. H. B. Mansfield, U. S. N., assistant; Master C. McR. Winslow, U. S. N.; Ensign W. B. Caperton, U. S. N.; Midshipman R. S. Sloan, U. S. N.	Hydrographic resurvey of Delaware Bay and River.
	15	Hydrography.....	Henry L. Marindin, assistant; W. I. Vinal, subassistant; Ensigns C. H. Amsden and E. M. Katz, U. S. N.	Hydrographic resurvey of Delaware River continued, with special reference to changes since earlier surveys.
	16	Triangulation	Spencer C. McCorkle, assistant; A. T. Mosman, assistant.	Triangulation of Delaware Bay and River continued.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION II—Continued.	No. 17	Topography	R. M. Bache, assistant	Topographic re-survey of the New Jersey shore of Delaware River, from Raccoon Creek, opposite Chester, Pa., to Kelly's Point, opposite New Castle, Del.
	18	Topography	C. T. Iardella, assistant	Topographic re-survey of the shore of the Delaware River from Chester, Pa., to New Castle, Del.
	19	Special triangulation.	Spencer C. McCorkle, assistant	Determination of the position of the new city hall, Philadelphia, Pa.
	20	Geodetic	Mansfield Merriman, acting assistant.	Occupation of stations for determining points in the triangulation of Pennsylvania.
SECTION III.				
Maryland, Virginia, and West Virginia, including bays, seaports, and rivers.	No. 1	Hydrography	Gershom Bradford, assistant; W. C. Willenbucher.	Hydrographic re-survey of Chincoteague Shoals. (See also Section II.)
	2	Triangulation	B. A. Colonna, assistant	Special triangulation for the determination of points in vicinity of Hampton Roads, Norfolk Harbor, and Elizabeth River. (See also Sections X and XVII.)
	3	Topography	C. M. Bache, assistant; Eugene Ellicott, assistant; J. B. Boutelle, aid.	Continuation of topographical survey, vicinity of Norfolk. (See also Section II.)
	4	Hydrography	Lieut. Commander Eugene B. Thomas, U. S. N., assistant; Lieut. Chas. C. Cornwell, U. S. N.; Masters F. A. Wilner and H. F. Reich, U. S. N.; Ensigns E. M. Katz, H. M. Witzel, and J. M. Orchard, U. S. N.	Hydrographic re-survey of Norfolk Harbor. (See also Sections II and VI.)
	5	Hydrography	J. S. Bradford, assistant	Examination of reported changes in Chesapeake Bay, and verification of data for the Coast Pilot, Vol. III. (See also Sections I and II.)
	6	Magnetic observations.	Charles A. Schott, assistant	Determination of the magnetic declination, dip, and intensity at the permanent station on Capitol Hill, Washington, D. C. (See also Section X.)
	7	Force of gravity	Charles S. Peirce, assistant; Edwin Smith, assistant; Henry Farquhar, E. D. Preston.	Absolute determinations of gravity by pendulum experiments at Baltimore and Washington. (See also Section I.)
	8	Telegraphic longitudes.	George W. Dean, assistant; Edwin Smith, assistant; C. H. Sinclair, subassistant; F. H. Parsons and Carlisle Terry, jr., aids.	Longitude of Cincinnati, Ohio, from Washington, D. C., determined by telegraphic exchanges of signals. (See also Sections XIII, XIV, and XV.)
	9	Telegraphic longitudes.	C. H. Sinclair, subassistant; F. H. Parsons, aid.	Longitude of Charlottesville, Va., from Washington, D. C., determined by telegraphic exchanges of signals.
	10	Topography	John W. Donn, assistant; D. B. Wainwright, subassistant; W. C. Hodgkins, aid.	Continuation of the detailed topographical survey of the District of Columbia.
	11	Topography	Charles Junken, F. C. Donn	Completion of the survey of the site for the new Naval Observatory in the District of Columbia.
	12	Triangulation	A. T. Mosman, assistant; W. B. Fairfield, extra observer.	Extension of the primary triangulation and reconnaissance in West Virginia, westward towards the Ohio River. (See also Section II.)
	13	Special reconnaissance and triangulation.	H. F. Walling	Reconnaissance, triangulation, and hypsometric observations in the region about Washington, D. C., for the construction of a general map.
	14	Magnetic observations.	J. B. Baylor, subassistant	Determinations of the magnetic declination, dip, and intensity completed at stations in Virginia and West Virginia. Latitude, longitude, and azimuth observed for magnetic purposes. (See also Sections VIII and XIII.)
	15	Geodesic leveling.	Andrew Braid, assistant	Completion of line of geodesic leveling from Sandy Hook, N. J., to Hagerstown, Md. (See also Sections II and XIV.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION IV.				
North Carolina, including coast, sounds, seaports, and rivers.	No. 1	Deep-sea soundings.	Commander J. R. Bartlett, U. S. N., assistant; Lieut. C. C. Cornwell, U. S. N.; Masters G. W. Mentz, Henry Morrell, and Lucian Flynne, U. S. N.; Ensign E. L. Reynolds, U. S. N	Lines of deep-sea soundings with serial temperatures run normal to the coast between Currituck light-house, N. C., and Jupiter Inlet, Fla. (See also Section VI.)
	2	Hydrography....	Lieut.-Commander W. H. Brownson, U. S. N., assistant.	Position of a shoal determined in vicinity of Cape Fear, N. C. (See also Sections V, VI, and VII.)
SECTION V.				
South Carolina and Georgia, including coast, sea-water channels, sounds, harbors, and rivers.	No. 1	Hydrography.....	Lieut.-Commander W. H. Brownson, U. S. N., assistant.	Examination of shoal reported off Georgetown entrance, and re-survey of part of Beaufort River, S. C. (See also Sections IV, VI, and VII.)
	2	Tidal observations	Lieut. B. D. Greene, U. S. Engineers.	Self-registering tide-gauge established at Fort Sumter, Charleston Harbor.
SECTION VI.				
Peninsula of Florida, from Saint Mary's River on the east coast, to Anclote Keys on the west coast, including the coast approaches, reefs, keys, seaports, and rivers.	No. 1	Deep-sea soundings.	Commander J. R. Bartlett, U. S. N., assistant; Lieut. C. C. Cornwell, U. S. N.; Masters G. W. Mentz, Henry Morrell, and Lucian Flynne, U. S. N.; Ensign E. L. Reynolds, U. S. N.	Lines of deep-sea soundings, with serial temperatures, run normal to the coast between Jupiter Inlet, Fla., and Currituck light-house, N. C. (See also Section IV.)
	2	Triangulation, topography, and hydrography.	C. H. Boyd, assistant; J. B. Weir, subassistant; Carlisle Terry, George F. Bird, and E. L. Taney, aids.	Continuation of the survey of Indian River southward to Jupiter Inlet, and determination of points on the beach for off-shore hydrography. (See also Section I.)
	3	Hydrography.....	Lieut.-Commander E. B. Thomas, U. S. N., assistant.	Continuation of the hydrographic survey of the east coast of Florida. (See also sections II and III.)
	4	Hydrography.....	Lieut.-Commander W. H. Brownson, U. S. N., assistant.	Hydrographic re-survey of Key West Harbor and Northwest Channel Bar. (See also Sections IV, V, and VII.)
	5	Triangulation	Joseph Hergesheimer, subassistant.	Triangulation of the west coast of Florida between Tampa Bay and Charlotte Harbor.
SECTION VII.				
Peninsula of Florida, west coast, from Anclote Keys to Perdido Bay, including coast approaches, ports, and rivers.	No. 1	Hydrography....	Lieut.-Commander W. H. Brownson, U. S. N., assistant.	Hydrographic survey of inner and outer bars of East Pass, Saint George's Sound; completion of hydrography in vicinity of Saint Joseph's Bay, and Cape San Blas; hydrography of the bar of Pensacola Harbor. (See also Sections IV, V, and VI.)
SECTION VIII.				
Alabama, Mississippi, Louisiana, and Arkansas, including Gulf coast, ports, and rivers.	No. 1	Magnetic observations.	J. B. Baylor, subassistant........	Determinations of the magnetic declination, dip, and intensity made at stations in Alabama. Latitude, longitude, and azimuth observed for magnetic purposes. (See also Sections III and XIII.)
SECTION IX.				
Texas and Indian Territory, including Gulf coast, bays, and rivers.	No. 1	Triangulation, topography, and hydrography.	F. W. Perkins, assistant; C. H. Van Orden, subassistant; Isaac Winston, aid.	Triangulation, topography, and hydrography of the coast of Texas between Galveston Bay and Sabine Pass. (See also Section XIV.)
	2	Triangulation and topography.	R. E. Halter, assistant; J. E. McGrath, aid.	Triangulation, measurement of base of verification, and topography on coast of Texas in vicinity of Laguna Madre.
SECTION X.				
California, including the coast, bays, harbors, and rivers.	No. 1	Special	James S. Lawson, assistant	Examination of localities at San Diego and at Los Angeles for selection of site of permanent magnetic station. (See also Sections XI and XVII.)
	2	Reconnaissance and triangulation.	Stehman Forney, assistant........	Continuation of reconnaissance and primary triangulation between Point Concepcion and Monterey.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION X—Continued.	No. 3	Topography	W. E. Greenwell, assistant	Topography of coast and adjacent islands from San Luis Obispo northward.
	4	Tidal observations	E. Gray	Tidal observations, with self-registering tide-gauge, continued at Saucelito, near entrance to San Francisco Bay.
	5	Topography	E. F. Dickins, subassistant	Topography of ground needed to fill gap in survey between Balenas and Table Mountain.
	6	Topography and triangulation.	L. A. Sengteller, assistant; E. F. Dickins, subassistant; P. A. Welker and Fremont Morse, aids.	Supplementary topography of San Francisco Bay and approaches. Points for topographical survey determined by triangulation.
	7	Hydrography	Lieut. W. T. Swinburne, U. S. N., assistant; Lieut. L. C. Heilner, U. S. N.; Master W. P. Elliot, U. S. N.; Ensign William Braunersreuther, U. S. N.; Midshipmen W. V. Bronaugh and F. V. Bostwick, U. S. N.	Continuation of coast hydrography northward and westward, between Bodega Bay and Point Arenas.
	8	Measurement of primary base-line.	George Davidson, assistant; Charles A. Schott, assistant; J. J. Gilbert, assistant; B. A. Colonna, assistant; H. W. Blair, subassistant; E. F. Dickens, subassistant; I. F. Pratt, subassistant; Werner Suess, mechanician; C. B. Hill, recorder.	Measurement of the Yolo primary base-line, and connection of base with stations of the trans-continental primary triangulation.
	9	Triangulation	A. F. Rodgers, assistant	Primary triangulation and reconnaissance extended northward from vicinity of Mendocino City toward Crescent City.
	10	Magnetic observations, and hydrographic reconnaissance.	Lieut.-Commander H. E. Nichols, U. S. N., assistant; Ensigns F. W. Coffin, C. F. Pond, W. V. Bronaugh, and F. M. Bostwick, U. S. Navy.	Determination of the three magnetic elements at stations on or near the coast between San Francisco and Sitka. Hydrographic reconnaissance of Wrangel Straits and Kaigani Straits. (See also Section XII.)
SECTION XI.				
Oregon and Washington Territory, including coast, interior bays, ports, and rivers.	No. 1	Triangulation, topography, and hydrography.	Cleveland Rockwell, assistant	Triangulation topography and hydrography of the Columbia River, between Saint Helen's, Portland, and Vancouver.
	2	Magnetic observations.	James S. Lawson, assistant	Determination of the magnetic elements at stations in Oregon, Washington Territory and Idaho. (See also Sections X and XVII.)
	3	Magnetic observations.	Lieut.-Commander H. E. Nichols, U. S. N., assistant; Ensigns F. W. Coffin, C. F. Pond, W. V. Bronaugh, and F. M. Bostwick, U. S. N.	Determination of the three magnetic elements at stations on the coast of Washington Territory. (See also Sections X and XII.)
	4	Triangulation and topography.	Eugene Ellicott, assistant	Topography of Port Orchard, and triangulation of Hood's Canal, Puget Sound, W. T. (See also Section III.)
	5	Hydrography	Lieut. Perry Garst, U. S. N., assistant; ensigns H. T. Mayo and J. A. Jordan, U. S. N.	Hydrographic survey of bays, inlets, and ports in Puget Sound, W. T.
SECTION XII.				
Alaska, including the coast, and the Aleutian Islands.	No. 1	Magnetic observations, and hydrographic reconnaissance.	Lieut.-Commander H. E. Nichols, U. S. N., assistant; Ensigns F. W. Coffin, C. F. Pond, W. V. Bronaugh, and F. M. Bostwick, U. S. N.	Determination of the three magnetic elements at stations on the coast between Sitka, Alaska, and San Francisco, Cal. Hydrographic reconnaissance of the waters of Southern Alaska. (See also Sections X and XI.)
	2	Tidal observations	W. J. Fisher	Tidal observations continued with self-registering tide-gauge at Saint Paul, Kadiak Island, Alaska.
SECTION XIII.				
Kentucky and Tennessee	No. 1	Telegraphic longitudes.	George W. Dean, assistant; Edwin Smith, assistant; C. H. Sinclair, subassistant; F. H. Parsons and Carlisle Terry, jr., aids.	Determination of the longitude of Nashville, Tenn., by telegraphic exchanges of signals with Cincinnati, Ohio. (See also Sections III, XIV, and XV.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Localities of work.	Persons conducting operations.
SECTION XIII—Continued.	No. 2	Triangulation	Carl Schenk, acting assistant	Continuation of the triangulation of the State of Kentucky.
	3	Triangulation	Prof. A. H. Buchanan, acting assistant.	Determination of stations in continuation of the triangulation of the State of Tennessee.
	4	Magnetic observations.	J. B. Baylor, subassistant	Values of the three magnetic elements determined at stations in Kentucky and Tennessee. Observations of latitude, longitude, and azimuth for magnetic purposes. (See also Sections III and VIII.)
SECTION XIV.				
Ohio, Indiana, Illinois, Michigan, and Wisconsin.	No. 1	Telegraphic longitudes.	George W. Dean, assistant; Edwin Smith, assistant; C. H. Sinclair, subassistant; F. H. Parsons and Carlisle Terry, jr., aids.	Determination of differences of longitude by telegraphic exchanges of signals between Cincinnati and Washington, Cincinnati and Nashville, Cincinnati and Saint Louis, and Vincennes and Saint Louis. Observations for latitude at Cincinnati and at Vincennes. (See also Sections III, XIII, and XV.)
	2	Geodetic	Prof. R. S. Devol, acting assistant.	Continuation of the triangulation of the State of Ohio.
	3	Geodetic	Prof. J. L. Campbell, acting assistant.	Determination of points in the triangulation of the State of Indiana.
	4	Reconnaissance	F. W. Perkins, assistant	Continuation of the reconnaissance for the extension of the primary triangulation eastward from the eastern boundary of Illinois. (See also Section IX.)
	5	Geodesic leveling.	Andrew Braid, assistant	Line of geodesic levels carried from Vincennes, Ind., toward Mitchell, Ind. (See also Sections II and III.)
	6	Triangulation	George A. Fairfield, assistant; J. B. Weir, subassistant.	Continuation of the primary triangulation in Illinois.
	7	Geodetic	Prof. J. E. Davies, acting assistant	Reconnaissance continued, and stations occupied in the triangulation of the State of Wisconsin.
	8	Magnetic observations.	Werner Suess, G. W. Suess	Determination of the values, absolute and relative, of the magnetic elements at the self-registering record station in Madison, Wis.
SECTION XV.				
Missouri, Kansas, Iowa, Nebraska, Minnesota, Dakota.	No. 1	Telegraphic longitudes.	George W. Dean, assistant; Edwin Smith, assistant; C. H. Sinclair, subassistant; F. H. Parsons and Carlisle Terry, jr., aids.	Longitude of Saint Louis, determined by exchange of telegraphic signals with Cincinnati. Longitude signals exchanged between Saint Louis and Nashville, Tenn., and between Saint Louis and Vincennes, Ind. (See also Sections III, XIII, and XIV.)
	2	Reconnaissance	F. D. Granger, assistant; Isaac Winston, aid; C. H. Zoll.	Reconnaissance for the extension of the primary triangulation in Missouri to the westward.
SECTION XVI.				
Nevada, Utah, Colorado, Arizona, and New Mexico.	No. 1	Triangulation	William Eimbeck, assistant; R. A. Marr, aid.	Occupation of stations for the extension of the primary triangulation in Nevada to the eastward.
	2	Triangulation	O. H. Tittmann, assistant; J. E. McGrath and G. F. Bird, aids.	Continuation to the eastward of the primary triangulation in Colorado.
SECTION XVII.				
Idaho, Wyoming, and Montana Territories.	No. 1	Magnetic observations.	James S. Lawson, assistant	Determination of the magnetic elements at stations in Idaho and Washington Territories; also in Oregon. (See also Sections X and XI.)
	2	Verification of boundary.	B. A. Colonna, assistant; T. P. Borden, aid.	Verification of the northern boundary of Wyoming Territory. (See also Section X.)
	Special		Dr. Thomas Craig	Investigations relative to tidal action and the tidal theory, and other mathematical and physical researches prosecuted in England and Europe.
	Special		Lieut. Samuel W. Very, U. S. N., assistant.	Determination of the magnetic declination, dip and intensity at stations on the northeastern coast of America.
	Special			Tidal record from the self-registering gauge established at Honolulu, Sandwich Islands.

APPENDIX No. 2.

Statistics of field and office work of the United States Coast and Geodetic Survey for the eighteen months ending June 30, 1882.

	Total to December 31, 1880.	December 31, 1880, to June 30, 1882.	Total to June 30, 1882.
RECONNAISSANCE.			
Area in square statute miles	275, 390	2, 860	278, 250
Parties, number of	....	2	....
BASE-LINES.			
Primary, number of	13	1	14
Subsidiary, number of	121	3	124
Primary, length of, in statute miles	79	11	90
Subsidiary, length of, in statute miles	271	30	201
TRIANGULATION.			
Area in square statute miles	153, 883	21, 314	175, 197
Stations occupied for horizontal measures, number of	9, 954	374	10, 328
Geographical positions determined, number of	18, 689	881	19, 570
Stations occupied for vertical measures, number of	600	39	639
Elevations determined trigonometrically, number of	1, 587	93	1, 680
Elevations determined by spirit leveling, number of bench-marks	1, 515	251	1, 766
Lines of spirit-leveling, length of, in statute miles	1, 836	326	2, 162
Triangulation and leveling parties, number of	....	37	....
ASTRONOMICAL WORK.			
Azimuth stations, number of	168	7	175
Latitude stations, number of	273	6	279
Longitude stations (new), telegraphic, number of	102	3	105
Longitude stations, chronometric or lunar, number of	110	0	110
Astronomical parties, number of	....	8	....
MAGNETIC WORK.			
Stations occupied, number of new	536	115	651
Permanent magnetic stations, number of	....	1	....
Magnetic parties, number of	....	8	....
TOPOGRAPHY.			
Area surveyed in square statute miles	27, 800	455	28, 255
Length of general coast, in statute miles	6, 190	178	6, 368
Length of shore line, in statute miles, including rivers, creeks, and ponds	78, 626	2, 252	80, 878
Length of roads, in statute miles	40, 495	521	41, 106
Topographical parties, number of	....	28	....
HYDROGRAPHY.			
Parties, number of	....	20	....
Number of miles (geographical) run while sounding	336, 033	9, 730	345, 763
Area sounded, in square geographical miles	82, 408	4, 982	87, 390
Miles run, additional to outside or deep-sea sounding	71, 159	1, 929	73, 186
Number of soundings	15, 422, 214	390, 424	15, 812, 638
Deep-sea soundings	....	337	....
Deep-sea temperature observations	....	1, 206	....

APPENDIX No. 2—Continued.

	Total to December 31, 1880.	December 31, 1880, to June 30, 1882.	Total to June 30, 1882.
HYDROGRAPHY—Continued.			
Tidal stations, permanent, number of	248	7	255
Tidal stations, temporary, number of	1,778	64	1,842
Tidal parties, number of	....	29	....
Current stations, number of	558	13	572
Current parties, number of	....	....	....
Specimens of bottom, number of	11,280	504	11,784
RECORDS.			
Triangulation, originals, number of volumes	3,249	489	3,738
Astronomical observations, originals, number of volumes	1,487	102	1,589
Magnetic observations, originals, number of volumes	485	40	525
Duplicates of above, number of volumes	3,850	529	3,879
Computations, number of volumes	3,156	264	3,420
Hydrographic soundings and angles, originals, number of volumes	8,114	336	8,450
Hydrographic soundings and angles, duplicates, number of volumes	1,299	209	1,508
Tidal and current observations, originals, number of volumes	3,313	64	377
Tidal and current observations, duplicates, number of volumes	2,135	51	2,186
Sheets from self-registering tide-gauges, number of	2,763	90	2,853
Tidal reductions, number of volumes	1,792	58	1,850
MAPS AND CHARTS.			
Topographical maps, originals	1,607	18	1,625
Hydrographic charts, originals	1,622	49	1,671
Reductions from original sheets	893	20	913
Total number of manuscript maps and charts	2,654	20	2,674
Number of sketches made in field and office	3,110	54	3,164
ENGRAVING AND PRINTING.			
Engraved plates of finished charts, number of	240	17	257
Engraved plates of preliminary charts, sketches, and diagrams, for the Coast and Geodetic Survey Reports, number of	609	23	632
Electrotype plates made	1,520	104	1,624
Finished charts published	320	44	364
Preliminary charts and hydrographic sketches published	....	....	....
Engraved plates of Coast Pilot charts	58	3	61
Engraved plates of Coast Pilot views	71	7	78
Printed sheets of maps and charts distributed	459,059	42,134	501,193
Printed sheets of maps and charts deposited with sale agents	173,827	21,623	195,450

APPENDIX No. 3.

Information furnished from the Coast and Geodetic Survey Office in reply to special calls during the year ending June 30, 1882.

Date.		Name.	Data furnished.
1881.			
July	2	Lieut. B. D. Greene, United States Engineers, Charleston, S. C., for General Q. A. Gillmore.	Loan of self-registering tide-gauge No. 33, with large cylinders and reading box, scale 1-10; also a copy of printed directions for using.
	5	Mr. Manton Marble, New York	Topographical survey of the east side of Hudson River, between Yonkers and Hastings; also autographic map vicinity of Newport, R. I.
	5	E. A. Grant, Secretary Polytechnic Society of Kentucky	Latitude and longitude of astronomical stations, Louisville, Ky.
	7	Charles Fish, Peabody Academy of Science, Salem, Mass.	The relation between the time of the tides at Portland and Augusta, Me.
	8	General George Thom, United States Engineers	Information relating to a tidal bench-mark at the mouth of the Merrimac.
	8	Mr. F. W. Dean, Cambridge, Mass	Shore-line survey of Campobello Island, near Eastport, Me.
	8	Lieut. Col. Charles E. Blunt, Corps Engineers, and Light-house Engineer.	Hydrographic survey of the "upper middle" Boston upper harbor (1861).
	9	S. F. von Frostner, civil engineer, Oswego	Pamphlets on secular change of magnetic declination and magnetic chart for 1875.
	11	Lieut. Col. W. P. Craighill, United States Engineers, Baltimore.	Distances between light-houses and geographical positions head of Chesapeake Bay, and on Elk River.
	12	W. R. Gregory, Warrenton, Va	Position and elevation of Ragged Rock, Blue Ridge, Va.
	12	Lieutenant-Colonel Craighill, Baltimore, Md	Information relating to tidal bench-marks on the Upper Chesapeake.
	16	H. Gannett, Geographer and Special Agent Tenth Census.	Geographical positions in Texas, Louisiana, Alabama, and Florida.
	18	Mr. P. O'Neil, San Francisco, Cal	Hydrographic approaches to Santa Inez River, Cal., north of Point Arguello, 1880.
	20	T. Kilbaugh, surveyor, Mount Carmel, Baltimore County, Md.	Magnetic pamphlet, with chart.
	26	A. L. Schellinger, architect, Ogdensburg, N. Y	Magnetic declination at Ogdensburg in 1838 and 1881, with annual change.
	26	W. H. Atwood, engineer, Jersey City, N. J	Descriptions of bench-marks in Jersey City.
	27	O. W. Gray & Son, Philadelphia	Unfinished proof of general coast chart No. XII, Cape San Blas to Tampa Bay, Fla.
	30	Dr. J. Magee, Albany, N. Y	Elevation of Perry's Peak, Mass.
Aug.	2	L. D. Haymond, Bedford County, Va	Elevation of the Peaks of Otter.
	4	Mr. J. P. Bogart, engineer Shell-Fish Commission, State of Connecticut.	Topographical and hydrographic work of the Connecticut shore, Section No. 2, from Cedar Point to New Haven Entrance combined, from the surveys made between 1835 and 1838, scale, 1-40,000.
	4	......do	Same, Section No. 3, from New Haven Entrance to Connecticut River.
	8	J. P. Bogart, New Haven, Conn	Geographical positions and descriptions of stations on Long Island Sound, vicinity of Falkner's Island.
	9	Mr. J. P. Bogart, engineer Shell-Fish Commission, State of Connecticut.	Topographical and hydrographic combined tracing from the early surveys of the Connecticut shore, Section No. 4, from Connecticut River to Fisher's Island Sound.
	11	......do	Copies of descriptions of stations along the Connecticut shore.
	11	Mr. Justus Roe, Patchogue, Long Island, N. Y	Copies of topographical and hydrographic survey of Port Jefferson, Long Island, N. Y., 1874.
	12	General C. B. Comstock, U. S. A., Mississippi River Commission.	List of geographical positions between Omeger and Lake Providence, La.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1881.			
Aug.	13	L. B. Buisse, merchant, New York City	Information about the tides on the north shore of Great South Bay, Long Island.
	13	James K. White, for National Amateur Regatta	Prediction of tides at Long Bridge, Washington, from 7th to 15th September, 1881.
	19	Mr. J. P. Bogart, engineer Shell-Fish Commission, State of Connecticut.	Surveys of the Connecticut shore, Section No. 1, from Byram River to Cedar Point.
	20	J. F. LeBaron, United States assistant engineer, Titusville, Fla.	Tidal data for use in surveying for a canal to connect Indian River and Mosquito Lagoon.
	22	D. Koppman, engineer Harbor and Land Commission Office, Boston, Mass.	Bench-mark and tides in Vineyard Haven Harbor.
	22	Mr. D. Koppman, engineer Board of Harbor and Land Commission Office, Boston.	Copy of the hydrographic survey of 1871 of Vineyard Haven, Mass., with projection covering the same, scale, 1-10,000.
	24	Mississippi River Commission	Sections of Mississippi River in one sheet, from Donaldsonville to Dichary's Plantation, scale, 1-5,000.
	24	George H. Cook, State Geological Survey, New Brunswick, N. J.	Bench-mark and tides at Sandy Hook.
	24	Prof. A. Hall, Washington, D. C.	Geographical position of Monticello, Va.
	26	C. Warren, Acting Commissioner Bureau of Education, Washington, D. C.	Geographical position of Paducah, Ky.
	29	H. Gannett, Census Office, Washington, D. C.	Geographical positions of fifteen stations, determined by the Coast and Geodetic Survey in principal cities of the United States.
	29	Vaux & Radford, civil engineers, New York City	Bench-mark at Sandy Hook, and tides near Seabright.
	29	Samuel McElroy, chief engineer Continental Railroad Company, New York.	Compiled chart Jersey Flats and Newark Bay, with adjacent topography, scale, 1-10,000.
	29	A. P. Butler, Commissioner of Agriculture of South Carolina.	Two sets of war maps of 1865 of South Carolina, with adjoining States.
	29	Mr. T. B. Ferguson, Assistant Commissioner United States Fish and Fisheries Commission.	Unfinished proof of coast chart No. 3, scale 1-80,000, Blue Hill and Frenchman's Bays, Me.
	30	B. Brett, Geneva, Ohio	Copy of paper on the secular change of the magnetic declination, and map.
Sept.	6	A. W. Phillips, Cheshire, Conn	Information relating to the tides at New London and New Haven.
	8	J. F. Le Baron, United States assistant engineer, Jacksonville, Fla.	Bench-marks on Indian River, Fla.
	8	General C. B. Comstock, United States Mississippi Commissioner.	Geographical positions on the Mississippi River between Lake Providence, La., and Greenville, Miss.
	9	Hon. A. C. Green, Frostburg, Md	Magnetic declination of Frostburg and magnetic chart of the United States.
	9	Mr. J. B. Bogart, engineer Shell-Fish Commission, State of Connecticut.	Topographic and hydrographic combined tracing of the Connecticut shore from Fisher's Island Sound to Pawcatuck River, being Section 5, scale 1-10,000, from the earlier surveys.
	9	Mr. Samuel Hill, Baltimore, Md	Topographical survey north side Chester River, vicinity of Shippen Creek, Md.
	10	Mr. Albert Mason, chairman Massachusetts Land and Harbor Commission.	Hydrographic survey of head of Buzzard's Bay, Mass., 1845.
	12	G. S. Kemper, surveyor, Harrisonburg, Va	Difference of the magnetic declination in 1746 and 1881 in Rockingham County, Va.
	13	E. A. Gieseler, engineer, Mauricetown, N. J	Geographical positions Maurice River, N. J.
	16	Prof. A. W. Phillips, Yale College, New Haven, Conn	Mode of predicting the tides for New Haven from the Coast Survey tables, and connected matters.
	17	General B. M. Harrod, State Engineer of Louisiana, New Orleans.	Supplies of record paper forms and leads for use on the tide-gauge No. 43; a copy of pamphlet on directions for observing tides.
	19	G. H. Brown, chief engineer, Eufaula, Ala	Magnetic declination at Eufaula in September, 1881.
	28	Prof. F. E. Nipher, Saint Louis, Mo	Magnetic declination, dip, and intensity of stations in Missouri, and of some stations in adjoining States.
Oct.	1	Hon. John S. Barbour	Information in relation to geographical positions and heights in West Virginia.
	3	W. M. Laffan, managing director Long Branch Improvement Company.	Hydrographic survey of 1880, of the eastern part of Hempstead Bay, Long Island, N. Y.
	5	Lieut. S. S. Leach, U. S. A., secretary Mississippi River Commission.	Description of stations on Mississippi River, from "Bass, to Hays, to Grane's, to Carolina."
	10	J. B. Bogart, New Haven, Conn	Geographical positions on Long Island Sound, near mouth of Connecticut River.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1881.			
Oct.	13	Mr. J. P. Bogart, engineer Shell-Fish Commission, State of Connecticut.	Geographical positions, and tracing locality of spires in Westbrook and Saybrook, Conn.
	14	M. P. Pierce, Wenonah, N. J.	Description of positions, and elevation of Pinehill, N. J.
	17	Lieut. B. H. Gilman, U. S. A.	Length of base-line at Fort Myer, Va.
	18	J. P. Bogart, New Haven, Conn.	Geographical positions on Connecticut River, and description of Lay's Hill, 2.
	18	J. L. Randolph, chief engineer Baltimore and Ohio Railroad Company, Baltimore.	Magnetic declination at Baltimore, Philadelphia, and Washington.
	20	Mr. D. E. Maxwell, general superintendent Florida Transit Railroad.	Unfinished proof of coast charts Nos. 3, 75, and 77, with latest soundings added by hand.
	21	Mr. Henry M. Drane, special assistant to general manager Savannah, Florida and Western Railway Company.	Unfinished proofs of coast charts Nos. 3, 82, and 83, scale 1–80,000, from Apalachee Bay to Cape San Blas, Fla., brought up by hand.
	24	C. C. Perkins, city surveyor's office, Boston, Mass.	Description of station, Blue Hill, Mass.
	25	Mr. Augustus Kurth, department of assessments, Brooklyn, N. Y.	Combined tracing of topographical surveys of 1838 of Shinnicock Bay, Long Island, N. Y.
	26	Mr. C. H. Kelly, Carrabelle, Liberty City, Fla.	Unfinished coast chart No. 82, scale 1–80,000, Apalachee Bay to Saint George's Island.
Nov.	1	J. Mechan, topographical engineer Department Public Works, Yonkers, N. Y.	Geographical positions, distances, and azimuths of triangulation east side of Hudson River, between Carmansville and Sing Sing.
	3	A. A. Schenck, Schenectady, N. Y.	Magnetic declination at Schenectady in 1859.
	3	Mr. Isaac Newton, chief engineer Croton Aqueduct	Topographical survey east side Hudson River, One hundred and fifty-second street to Yonkers, and list of geographical positions between New York City and Croton.
	8	......do	Same, Yonkers to Tarrytown, N. Y.
	8	Mr. Gustaf Petterson, Galveston, Tex.	Unfinished coast chart No. 92, Chandeleur and Breton Sounds, La., scale 1–80,000.
	10	General G. K. Warren, United States Corps of Engineers.	Sketch showing positions and bearings of Fish Rock, Narragansett Bay, R. I.
	11	Mr. Nathaniel H. Bishop, president American Canoe Association.	Coast chart No. 58, Saint Mary's River, entrance, southward to latitude 30° N., with additions by hand.
	11	......do	Coast chart No. 60, Halifax River to Mosquito Lagoon, with additions by hand.
	11	......do	Coast chart No. 61, Mosquito Lagoon to southern end Merrett's Island, with additions by hand.
	14	Mr. William N. Dykman, No. 189 Montague street, Brooklyn, N. Y.	Charts of New York Bay and Harbor, scale 1–80,000, issued in 1845, with changes in shore-line from the surveys made 1855–'56, 1860, 1878–'79, and 1880 added by hand.
	16	Lieut. Col. George H. Mendell, United States Corps of Engineers.	Hydrographic survey of Suisun Bay, Cal., made in 1878.
	18	Commander George Dewey, U. S. N., office Light-House Board.	Position of Coney Island tower, and trigonometrical points vicinity of Coney Island, N. Y.
	18	Prof. W. M. Fontaine, University of Virginia	Table of heights of stations in the Blue Ridge, Va.
	19	Mr. Isaac Newton, chief engineer Croton Aqueduct	Topographical survey east side of Hudson River, from Tarrytown to Croton River, scale 1–10,000.
	19	Lieutenant-Colonel Craighill, Baltimore, Md	A copy of tide-tables for the Atlantic coast of the United States.
	21	Mr. William N. Dykman, No. 89 Montague street, Brooklyn, N. Y.	Charts of New York Bay and Harbor, scale 1–80,000, issued in 1845, with changes in shore-line, from the surveys made in 1855–'56, 1860, 1878–'79, with that of 1880 added by hand.
	25	E. A. Bonet, chief engineer Utica and Black River Railroad, Clayton, Jefferson County, N. Y.	Information on bibliography of terrestrial magnetism, and the secular change of the declination.
	26	Mr. Otis Ashmore, principal of Harlem High School, Ga., at request of General W. B. Hazen, Chief Signal Officer.	Tide-table for Savannah, Ga.
	30	Mr. Burgwyn, engineer on James River improvement	Tidal data for Shirley Wharf Station on James River, Va.
	30	C. P. E. Burgwyn, assistant engineer James River improvement, Richmond, Va.	Descriptions of stations, triangle side computations, and geographical positions, James River, from Jamestown to City Point, latest survey.
Dec.	1	General William B. Hazen, Chief Signal Officer	Profile of bottom from north end of Block Island to Rocky Point, L. I.
	5	Col. L. P. Miller, Georgetown, S. C.	Difference in time of high water between the points where Mosquito Creek opens into Winyah Bay and into North Santee River.
	7	Mr. Oscar Iasigi, Ottoman consul-general	Unfinished proof coast chart No. 3, scale 1–80,000, Mount Desert Island, brought up by hand.
	8	Mr. Ernest A. Des Marets, stock broker, 62 Broadway, New York.	Hydrographic survey Cape Canaveral, Fla., from survey of 1878, with additions of 1881.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1881.			
Dec.	16	Mr. Otis Ashmore, principal of Harlem High School, Ga.	Copy of tide-tables for the Atlantic coast for 1882; copy of predictions for Savannah for 1883.
	16	Mr. William B. Brend, Special Agent Census Office, New Haven, Conn.	Difference of level between extreme high and low water at New Orleans.
	17	Long Island Historical Society	Length and area of Long Island, N. Y.
	19	George H. Cook, State Geological Survey, New Brunswick, N. J.	Matter relating to bench-mark and tides at railroad depot, Sandy Hook, N. J.
	20	Mr. Marshall Parks, Norfolk, Va	Hydrographic survey of Club-foot Canal, connecting Neuse River with Beaufort Harbor, N. C.
	22	Thomas Turtle, United States Corps of Engineers; office, Baltimore, Md.	Bench-marks on Cape Fear River at and below Wilmington, to connect with tide-work above Wilmington for river improvements.
	22	G. W. Campbell, surveyor, Shuqualak, Miss	Magnetic declination.
	27	Lieut. Col. G. K. Warren, Corps of Engineers	Hydrographic survey of Edgartown Harbor, Mass., of 1846.
1882.			
Jan.	3	J. S. Hittell, San Francisco	Approximate heights Coast and Sierra Nevada Ranges, California and Nevada Mountains.
	4	Richard Lamb, civil engineer, Brown University, Providence, R. I.	Tide-table for Norfolk, Va., for use in the mayor's office at Norfolk.
	6	Maj. T. B. Ferguson, assistant, United States Fish Commission.	Topographical survey of the western shore of Chesapeake Bay from Point Lookout to Point No Point, including Saint Jerome's Creek.
	6	Rev. Sheldon Jackson	Copy of shore-line and river courses from Alaska chart.
	10	Mr. Otis Ashmore, principal of Harlem High School, Ga.	Information relating to the tide-tables for the Atlantic coast.
	12	O. D. Barrett, Washington, D. C	Geographical positions vicinity of Elliot's Knob, Va.
	14	E. V. d'Imillier, civil engineer, Philadelphia, Pa	Geographical position of "Blacksport" and directions from it.
	14	Prof. Alexander Agassiz, Cambridge, Mass	Two copies of sailing charts A and B, showing 460 deep-sea soundings and bottoms, 300 current observations, 17 profiles of sounding lines, with temperature and velocity of currents.
	14	Commander J. R. Bartlett, U. S. N	Do.
	14	Hydrographic Office	Copy of sailing chart C, showing current and wind observations, taken by Commander C. D. Sigsbee, U. S. N., assistant Coast and Geodetic Survey.
	17	Capt. C. A. Abbey, United States Revenue Service	Unfinished chart of the coast of Maine, scale 1–40,000; of Blue Hill, with Union River Bay, and Frenchman's Bay, and approaches to Blue Hill Bay, and Eggemogin Reach, brought up by hand.
	18	Lieut. Col. W. P. Craighill, Corps of Engineers	Topography of James River in three sheets: 1. From Richmond to Kingsland Creek, 1878–'79; 2. Kingsland Creek to Jones' Neck, 1877; 3. Jones' Neck to City Point, 1877.
	18	R. S. Floyd, president Lick trustees, San Francisco, Cal	Geographical position of Mount Hamilton, Cal.
	21	J. T. Gardner, director New York State Survey, Albany	Height of Mount Rafinesque and Helderberg Stations above the level of the ocean.
	31	Lieut. Col. Charles E. Blunt, Corps of Engineers	Hydrographic survey of Hypocrite Reef, off Damariscotta River, Me.
Feb.	2	Mr. William Thompson, president of the Inland and Seaboard Coasting Company.	Tides at Cape Henlopen.
	7	Maj. G. L. Gillespie, United States Engineers	Bench-marks on Lake Champlain.
	7	......do	Geographical positions in the vicinity of Burlington, Vt., Plattsburg, N. Y., Port Henry, N. Y., Swanton, Vt., and Ticonderoga, N. Y.
	7	H. G. Wright, Chief of Engineers, U. S. A	Position of intersection of boundary of Mississippi and Louisiana on the east bank of the Mississippi River, and geographical position of Vicksburg.
	8	Prof. Spencer F. Baird, Secretary of the Smithsonian Institution.	Tidal data relating to Wood's Holl, Mass., for use of United States Fish Commission.
	8	Lieut. Commander H. H. Gorringe, U. S. N	Shore-line survey of the Columbia River, from near Kalama to mouth of Willamette, surveys of 1879–'80.
	13	Theodore Rogers, esq., New York	Coast charts Nos. 42 and 43, eastern and middle parts of Pamplico Sound, N. C., scale 1–80,000, brought up by hand.
	13	R. E. Hancock, New Berne, N. C	Do.
	18	James P. Bogart, engineer Connecticut Shell-Fish Commission.	Four projections, scale 1–20,000, coast of Connecticut, with shore-line reduced thereon.
	20	Lieut. Col. William P. Craighill, Corps of Engineers	Topographical survey of the James River in two sheets, viz: 1. From City Point to Sloop Point, survey of 1873–'75; 2. From Sloop Point to Hog Point, survey of 1873–'75.
	28	Mr. A. B. Hill, assistant city engineer, New Haven, Conn.	Topographical survey of Connecticut coast, vicinity of Oyster River Point, 1837–1872.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1882.			
Feb.	25	Mr. George A. Stockwell, Journal office, Providence, R. I.	Predictions of the tides for the year 1883 for Newport, R. I., to use in an almanac.
	28	J. T. R. R. Carroll, Guilford, Howard County, Md	Magnetic declination in Howard County, and copy of secular change paper.
Mar.	10	G. E. Ladshaw, Pacolett Depot, Spartanburg, S. C	Magnetic data for the State of South Carolina.
	13	Charles L. Coxe & Co., New York	On the lowest tides at New York in February, 1882.
	13	Merritt Trimble, New York	Topographical survey of the head of Somes' Sound, Mount Desert Island, Me.
	15	William H. Power & Co., New York	Unfinished proof of coast chart No. 82, scale 1-80,000, Saint George's Sound and Apalachee Bay, Fla.
	16	Mr. E. B. Freeman, Norfolk, Va	Hydrographic survey southern branch Elizabeth River, Va., from navy-yard to Dismal Swamp Canal, 1872-'73.
	16	James P. Perkins, county surveyor, Myers, Fla	Magnetic declination in Monroe County, Fla.
	22	Mr. O. H. Tripp, civil engineer, Blue Hill, Me	Unfinished coast chart No. 3, scale 1-80,000, Frenchman's and Blue Hill Bays, Me.
	23	W. C. Van Bibber, Baltimore, Md	Table giving number of miles of tide-water by counties, Atlantic Ocean coast, Chesapeake Bay and its rivers on both sides, and east bank of Potomac River and its branches, with the boundaries of the State of Maryland.
	24	Lieut. Col. F. Perrier, Etat Major-General Service Geographique, France.	Topographical survey of Saint Augustine, Fla., and vicinity, to be used in connection with Transit of Venus.
	24	Secretary of War	Unfinished proof entrance to San Francisco Bay, Cal., showing in red the changes about Oakland to January, 1882.
	24	Lieut. Col. W. P. Craighill, Corps of Engineers	Hydrographic survey of James River, from Day's Point to Mulberry Point, made in 1871-'72 (1-20,000).
	24	E. A. Giesseler, assistant engineer, United States Engineer Office, 1125 Girard street, Philadelphia, Pa.	Cotidal lines on Atlantic coast of the United States, and corrected establishments for Atlantic ports.
	25	Lieut. Col. W. P. Craighill, Corps of Engineers	Hydrographic survey of James River, from Day's Point to Mulberry Point, made in 1854-'55 (1-20,000).
	25	S. P. Thompson & Co., Baltimore, Md., at request of General Gorman.	Twenty-five copies of chart Delaware and Chesapeake Bays No. 376, with proposed routes of Sassafras and Choptank Canal shown in colors.
	30	Mr. Theo. Buhler, Corpus Christi, Tex	Unfinished proof of coast chart No. 109, scale 1-80,000, Aransas Pass, Aransas and Copano Bays, Tex., brought up by hand.
April	1	Rev. Sheldon Jackson	Hydrographic survey of Harakan Straits, American Bay, Alaska.
	3	Mr. R. W. Templeman, Baltimore, Md	Hydrographic survey Curtis Creek, Patapsco River, Md.
	4	O. W. Gray & Son, Philadelphia, Pa	Geographical positions in Dakota Territory.
	4	Prof. George H. Cook, State Geologist, New Jersey	A copy of about forty-five tidal bench-marks on or near the shores of New Jersey.
	5	Mr. C. Stoughton, Washington, D. C	Range of tides at Sandy Hook, for use before the Committee on Commerce of the House of Representatives.
	8	Mr. R. A. Bigelow, of Yale Boating Club.	Predicted times of high waters at New London, Conn., for one week in June, 1883, and one in 1884.
	10	Q. A. Gillmore, Lieutenant Colonel of Engineers, Brevet Major General, U. S. A.	Relating to the elevation of the upper portion of Saint John's River, Fla., above the Atlantic.
	10	J. B. Holbrook, Lebanon, Warren County, Ohio	Information of annual change of the magnetic declination.
	10	Charles Holmes, East Saginaw, Mich	Geographical position and magnetic declination at Saginaw.
	10	W. D. Dawson, Halifax, Nova Scotia	Magnetic declination at four stations in Nova Scotia.
	11	Col. William W. Blackford, Lynchburg, Va	Topographical survey vicinity of Norfolk, Va., 1874, scale 1-10,000.
	12	Lieut. Col. William P. Craighill, Corps of Engineers	Topographical survey of the James River, from Hog Point to Newport News Point.
	13	James C. Post, Captain Engineers, U. S. A	Tidal bench-marks at the mouth of Saint John's River, Fla., and entrance to Cumberland Sound.
	14	R. W. Templeman & Co., 37 Lexington street, Baltimore, Md.	Topographical survey of the shores of Patapsco River, from Brooklyn to Curtis Creek, and Furnace Creek, Md.
	17	Capt. J. H. Merryman, United States Revenue Marine	Geographical position of Station West 2, near Long Branch, N. J.
	20	J. R. Proctor, Kentucky Geological Survey, Frankfort, Ky.	Geographical positions determined by the Coast and Geodetic Survey in Kentucky.
	22	Hon. William Lamb, mayor of Norfolk, Va	Topographical survey of 1882 of Lambert Point, Elizabeth River, Va.
	22	Col. William W. Blackford, Lynchburg, Va	Topographical survey of 1882, country between Fort Norfolk and Tanner's Creek, Elizabeth River, Va.
	27	C. C. Hamman, attorney at law, Perth Amboy, N. J	Information bearing on magnetic declination.
	27	Franz Meckel, civil engineer, Mauch Chunk, Pa	Information about magnetic declination.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1882.			
May	4	Prof. H. C. Lewis, Philadelphia, Pa	Magnetic dip at Philadelphia, April, 1882.
	6	E. P. Austin, Boston, computer for almanacs	A copy of the tidal predictions for Boston for 1883, for use in making a local almanac for Boston.
	10	Mr. Temple, Prince George's County, Md	Present bearings of some old magnetic boundary lines.
	11	T. C. Brown, county surveyor, Elyria, Ohio	Magnetic pamphlet and chart.
	15	G. A. Stockwell, office Providence Journal, Providence, R. I.	Latitude and longitude of Providence, and difference of time between Washington and Boston, and Washington and Providence.
	17	R. Keith, Easton, Md	A copy of the tidal predictions for Philadelphia for 1883.
	18	Maj. Powell, Director Geological Survey	Latitude, longitude, azimuth, and distance, Mount Shasta and Lassen's Butte.
	20	Alfred P. Boller, civil engineer, 71 Broadway, N. Y	Survey of the Thames River, vicinity of New London, Conn.
	22	W. W. Phillips, superintendent of construction, Marietta and North Georgia Railroad, Jasper, Ga.	Height of station, Grassy Knob, Ga.
	24	A. D. Blackinton, civil engineer, Rockland, Me	Geographical positions and descriptions of four stations, vicinity of Rockland, Me.
	29	G. W. Taylor, Pickens, S. C	List of elevations of prominent places in South Carolina determined by the Coast and Geodetic Survey.
	31	Col. William Ludlow, U. S. A., in charge harbor works of Delaware River.	Twenty sheets of blank "forms for reductions of tides No. 1," sent by request of Henry Mitchell.
June	3	A. Walling, jr., Keyport, N. J	Topographical surveys of Keyport, N. J., from maps of 1836 and 1856, scale 1-10,000.
	3	General W. G. Le Duc	Tracing of hydrographic reconnaissance, Lower California, from San Diego Bay to Point Conoas.
	3	Hon. R. L. Gibson, House of Representatives	Length of the sea-coast of the United States, including that of Alaska.
	3	G. A. Hines, Brattleboro, Vt	Secular change of magnetic declination in vicinity of Brattleboro, Vt.
	3	J. Tallock, jr., Williamstown, Mass	Position and height of Greylock Station.
	6	Inspector of fifth light-house district	Magnetic declination for seventy-six positions in Maryland, Virginia, and North Carolina.
	7	G. E. Waring, Special Agent of the Tenth Census of the United States, Newport, R. I.	Geographical positions of cities and towns determined by the United States Coast and Geodetic Survey.
	12	Mr. I. M. Forbes, Boston, Mass	Topographical survey east from Santa Barbara, Cal.
	12	Mr. G. A. Horle, New York	Unfinished proof of coast chart No. 109, Aransas and Copano Bays, Tex., brought up by hand.
	22	H. Poole, 42 West Tupper street, Buffalo, N. Y	A copy of tide tables for the Atlantic coast for 1883.
	23	Mississippi River Commission	Seven maps of the Mississippi River from head of passes to Donaldsonville, compiled upon a scale of one inch to the mile, from the original plane-table sheets of the United States Coast and Geodetic Surveys; also on diagram chart of the above map, scale 1-400,000.
	23	Capt. J. E. Jouett, U. S. N., commanding United States steamer Wyoming.	Hydrography of Port Royal Bay and Broad River, S. C.
	29	H. M. Stanley, Prospect Station, Giles County, Tenn	Magnetic declination at Pulaski, Tenn., and annual changes.

APPENDIX No. 4.

DRAWING DIVISION.

Charts completed or in progress during the year ending June 30, 1882.

1. Topography. 2. Hydrography. 3. Drawing for photolithographic reproduction. 4. Engraving on stone. 5. Verifying. 6. New longitudes.

Number of chart. Series.	Catalogue.	Title of charts.	Scale.	Draughtsmen.	Remarks.
		ATLANTIC COAST.			
		Sailing charts:			
II	2	Nantucket to Cape Hatteras	1-1,200,000	2. A. Lindenkohl.	In progress.
III	3	Cape Hatteras to Mosquito Inlet	1-1,200,000	2. A. Lindenkohl.	Do.
IV	4	Mosquito Inlet to Key West, with Bahama Banks	1-1,200,000	2. A. Lindenkohl.	Do.
B	....	Cape Hatteras to Key West, with subsketches	1-1,200,000	A. Lindenkohl	Do.
C	....	Gulf of Mexico	1-1,200,000	2. C. Junken, A. Lindenkohl	Do.
		General coast charts, Atlantic and Gulf Coasts:			
II	7	Cape Ann to Gay Head	1-400,000	2. C. Junken	Do.
III	8	New position of light vessels New York Harbor.	1-400,000	— T. J. O'Sullivan, A. B. Graham	Do.
VI	11	Cape Hatteras to Cape Romain	1-400,000	2. A. Lindenkohl	Completed.
VII	12	Cape Romain to Saint Mary's Entrance	1-400,000	2. A. Lindenkohl	In progress.
VIII	13	Saint Mary's Entrance to Cape Cañaveral	1-400,000	2. A. Lindenkohl	Completed.
XIII	18	Cape San Blas to Mississippi Passes	1-400,000	1. A. Lindenkohl	In progress.
XVI	21	Galveston to the Rio Grande	1-400,000	2, 6. C. Junken. 1, 2. A. Lindenkohl	Completed.
....	376	Delaware and Chesapeake Bays	1-400,000	1. A. Lindenkohl. H. Lindenkohl	In progress.
6	676	San Francisco to Point Arena	1-200,000	1. A. Lindenkohl	Completed.
		Coast charts:			
3	103	Frenchman's and Blue Hill Bays	1-80,000	1, 2. A. Lindenkohl. 2. E. J. Sommer	In progress.
20	120	New York Bay and Harbor (new position of light-vessels).	1-80,000	— T. J. O'Sullivan. A. B. Graham	Do.
21	121	Sandy Hook to Barnegat Inlet (new position of light-vessels).	1-80,000	— T. J. O'Sullivan. A. B. Graham	Do.
19	119	Southern coast of Long Island	1-80,000	2. A. Lindenkohl. H. Lindenkohl. L. Karcher.	Do.
25	125	Delaware Bay and River, middle sheet	1-80,000	5. C. Junken. 2. A. Lindenkohl	Do.
28	128	Isle of Wight to Chincoteague Inlet	1-80,000	2. A. Lindenkohl	Do.
31	131	Entrance to Chesapeake, Hampton Roads, &c	1-80,000	1, 2. A. Lindenkohl. 2. H. Lindenkohl.	Do.
36	136	Magothy River to Head of Bay	1-80,000	2. A. Lindenkohl	Do.
53	153	Winyah Bay to Long Island	1-80,000	2. C. Junken	Do.
61	161	Cape Cañaveral and vicinity	1-80,000	2. A. Lindenkohl	Completed.
71	171	Rebecca Shoal to the Tortugas	1-80,000	2. C. Junken	Do.
77	177	Tampa Bay	1-80,000	2. C. Junken	In progress.
86	186	Choctawhatchee Inlet to Pensacola Entrance	1-80,000	2. A. Lindenkohl	Do.
112	212	Rio Grande, northward, to latitude 26° 30′	1-80,000	1. A. Lindenkohl	Completed.
		HARBOR CHARTS.			
6	311	Penobscot River and Belfast Bay, Me	1-40,000	5. E. J. Sommer	In progress.
9	307	Blue Hill and Union River Bays, Me	1-40,000	1. E. J. Sommer	Do.
10	306	Frenchman's Bay and Somes Sound, Me	1-40,000	2. A. Lindenkohl. C. Junken	Do.
....	348	Wood's Hole, Mass	1-20,000	2. C. Junken. H. Lindenkohl	Do.
....	384	Patapsco River, Md	1-60,000	2. A. Lindenkohl	Do.

APPENDIX No. 4—Continued.

Number of chart. Series.	Number of chart. Catalogue.	Title of charts.	Scale.	Draughtsmen.	Remarks.
1	388	Potomac River, entrance to Piney Point	1–60, 000	1, 2. A. Lindenkohl	In progress.
2	389	Potomac River, Piney Point to Lower Cedar Point	1–60, 000	2. A. Lindenkohl	Do.
3	390	Potomac River, Lower Cedar Point to Indian Head.	1–60, 000	2. A. Lindenkohl	Do.
4	391	Potomac River, Indian Head to Georgetown	1–40, 000	2. A. Lindenkohl	Do.
1	....	Changes in the Delaware River, between Bridesburg and Kensington.	1–10, 000	3. E. J. Sommer. T. J. O'Sullivan. H. Lindenkohl.	Completed.
2	....	Changes in the Delaware River, between Kensington and Kaighn's Point.	1–10, 000	3. E. J. Sommer. T. J. O'Sullivan H. Lindenkohl.	
3	....	Changes in the Delaware River, between Kaighn's Point and Horseshoe Shoal.	1–10, 000	3. E. J. Sommer. T. J. O'Sullivan. H. Lindenkohl.	
4	....	Changes in the Delaware River, between Horseshoe Shoal and Fort Mifflin.	1–10, 000	3. E. J. Sommer. T. J. O'Sullivan. H. Lindenkohl.	
1	....	Delaware River, Bombay Hook to Cherry Island Flats.	1–40, 000	3. A. Lindenkohl. H. Lindenkohl	Completed.
2	....	Delaware River, Cherry Island Flats to Bridesburg.	1–40, 000	3. A. Lindenkohl. H. Lindenkohl	In progress.
4	402*d*	James River, from City Point to Kingsland Creek	1–25, 000	3. H. Lindenkohl	Completed.
4	402*e*	James River, Kingsland Creek to Richmond	1–25, 000	3. H. Lindenkohl	Do.
....	402*e*	James River, Kingsland Creek to Richmond	1–20, 000	1. A. Lindenkohl. E. J. Sommer. A. B. Graham.	In progress.
....	447	Saint Simon's Sound, Brunswick Harbor, Ga	1–40, 000	2. C. Junken. H. Lindenkohl	Do.
....	453	Extension of Fernandina Entrance	1–20, 000	2. C. Junken	Do.
....	484	Saint Mark's River, Fla	1–20, 000	1. P. Erichsen	Do.
....	484	Saint Mark's River (new hydrography)	1–30, 000	2. C. Junken	
....	521	Pass Cavallo, Tex	1–20, 000	3. E. J. Sommer	Completed.
....	621	San Francisco Bay and entrance	1–50, 000	2. A. Lindenkohl. L. Karcher. 1. E. J. Sommer.	In progress.
....	621*a*	San Francisco Bay and entrance	1–40, 000	1. C. Junken	
1	640	Columbia River, entrance to Astoria	1–40, 000	2. C. Junken	
4	641*b*	Columbia River, Grim's Island to Kalama	1–40, 000	3. L. Karcher	
....	644	Budd's Inlet, Puget Sound	1–25, 000	3. T. J. O'Sullivan	
....	....	Re-plotting hydrographic sheet of Newport News Point.	1–10, 000	2. C. Junken	
....	....	Re-plotting hydrographic sheet of San Pedro to Santa Cruz, Cal.	1–100, 000	2. C. Junken	
		MISCELLANEOUS.			
....	....	Drawing of leveling instrument and attachment to dividing machine.	....	P. Erichsen	Completed.
....	....	Diagram chart, Gulf of Mexico and Caribbean Sea.	1–8, 000, 000	3. A. Lindenkohl	
....	....	Plan of meridian telescope (Davidson's)	....	P. Erichsen	
....	....	Current and temperature chart, Alaska Coast	....	3. E. J. Sommer	
....	....	Triangulation of Mississippi River	....	3. E. J. Sommer	
....	....	Map of topography between Norfolk and Lynn Haven River, Va.	1–25, 000	3. T. J. O'Sullivan	
....	....	Sunken Rocks off Timber Gulch and Russian River Cove, Cal.	1–5, 000	3. H. Lindenkohl	
....	....	Transcontinental triangulation sketch from Pacific coast eastward.	1–2, 000, 000	3. T. J. O'Sullivan. H. Lindenkohl	
....	....	Plan of 20-inch theodolite and prismatic transit	....	P. Erichsen	
....	....	Diagrams of telegraphic apparatus	....	4. H. Lindenkohl	
....	....	Map of Behring Strait	....	4. H. Lindenkohl	
....	....	Plan of Fauth's chronograph	....	P. Erichsen	
....	....	Plan of 45 and 46 inch transits	....	P. Erichsen	
....	....	Plan of alt-azimuth and magnetometer	....	P. Erichsen	
....	....	Chart of Washington and Georgetown Harbors	1–15, 840	3. A. Lindenkohl. H. Lindenkohl	
....	....	Statistics in miles, tidal coast of Maryland	....	L. Karcher	
....	....	Sketch showing position of magnetic stations	....	L. Karcher	
....	....	Plan of new base apparatus	....	P. Erichsen	
....	....	New base map of United States, showing location of Bache Fund magnetic stations.	1–7, 000, 000	3. T. J. O'Sullivan	

APPENDIX No. 5.

ENGRAVING DIVISION.

Plates completed, continued, and commenced during the year ending June 30, 1882.

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering.

Catalogue No.	Plate No.	Title of plates.	Scale.	Engravers.	Date of completion.	Remarks.
		COMPLETED.				
		ATLANTIC AND GULF COASTS.				
10	1039	General coast chart No. 5, Cape Henry to Cape Lookout.	1-400,000	3. H. M. Knight, W. A. Thompson. 4. E. A. Maedal, A. Petersen.	June, 1882	Edition of 1882.
18	1043	General coast chart No. 13, Cape San Blas to Mississippi Passes.	1-400,000	3. W. A. Thompson. 4. E. A. Maedel, E. H. Sipe.	June, 1882	First edition.
128	1230	Coast chart No. 28, Isle of Wight to Chincoteague Inlet.	1-80,000	3. H. M. Knight, W. A. Thompson. 4. E. A. Maedel, J. G. Thompson, W. H. Davis.	Mar., 1882	Edition of 1882.
144[1]	1649	Coast chart No. 44[1], sheet No. 1, Pamlico Sound, Pamlico River.	1-80,000	3. H. M. Knight. 4. T. Wasserbach, A. C. Ruebsam.	Aug., 1881	Edition of 1881.
171	1407	Coast chart No. 71, Rebecca Shoal to the Dry Tortugas.	1-80,000	3. H. M. Knight, W. A. Thompson. 4. E. A. Maedel, J. G. Thompson, A. C. Ruebsam.	Mar., 1882	First edition.
183	1347	Coast chart No. 83, Apalachicola Bay to Cape San Blas.	1-80,000	2, 3. W. A. Thompson. 3, 4. J. G. Thompson 4. E. A. Maedel, A. C. Ruebsam.	Jan, 1882	First edition.
186	1290	Coast chart No. 86, Choctawhatchee Inlet to Pensacola Entrance.	1-80,000	3. W. A. Thompson. 4. E. A. Maedel, A. Petersen.	July, 1881	Edition of 1881.
207	1334	Coast chart No. 107, Matagorda Bay	1-80,000	2, 3. W. A. Thompson. 4. E. A. Maedel, J. G. Thompson, W. H. Davis.	Mar., 1882	Edition of 1882.
292	1686	Harbor chart, Mount Desert Island, Me.	1-40,000	1, 2. W. A. Thompson. 4. J. G. Thompson.	June, 1882	First edition.
309	1195	Harbor chart, East Penobscot Bay......	1-40,000	2, 3. W. A. Thompson. 4. E. A. Maedel, J. G. Thompson, W. H. Davis.	June, 1882	First edition.
311	1259	Harbor chart, Penobscot River and Belfast Bay.	1-40,000	1, 2, 3. W. A. Thompson. 3. R. F. Bartle. 4. E. A. Maedel, A. Petersen, A. C. Ruebsam.	Apr., 1882	First edition.
333	823	Harbor chart, Rockport Harbor, Mass ..	1-20,000	2, 3. W. A. Thompson. 4. A. C. Ruebsam.	Mar., 1882	Reissued.
365	826	Harbor chart, Little Captain's Island and Great Captain's Island.	1-20,000	2, 3, 4. E. H. Sipe......................	Feb., 1882	Reissued.
376	453	Harbor chart, Delaware and Chesapeake Bays.	1-400,000	1, 2, 3. W. A. Thompson. 4. W. H. Davis, A. C. Ruebsam.	May, 1882	Reissued.
401*a*	1445	Harbor chart, James River No. 1, Hampton Roads to Point of Shoals.	1-40,000	1, 2, 3. W. A. Thompson. 3. H. M. Knight. 4. E. A. Maedel, J. G. Thompson.	Jan., 1882	First edition.
401*b*	1555	Harbor chart, James River No. 2, Point of Shoals to Sandy Point.	1-40,000	2. W. A. Thompson. 4. E. A. Maedel, H. M. Knight.	Jan., 1882	First edition.
401*c*	1495	Harbor chart, James River No. 3, Sandy Point to City Point.	1-40,000	4. E. A. Maedel, H. M. Knight, J. G. Thompson, A. C. Ruebsam.	Jan., 1882	First edition.

APPENDIX No. 5—Continued.

Catalogue No.	Plate No.	Title of plates.	Scale.	Engravers.	Date of completion.	Remarks.
		COMPLETED.				
		ATLANTIC AND GULF COASTS—Continued.				
406	851	Harbor chart, North Landing River	1-40, 000	4. A. C. Ruebsam	June, 1882	Edition of 1882.
424	1161	Harbor chart, Cape Fear River Entrance	1-30, 000	1, 3. W. A. Thompson. 4. J. G. Thompson, W. H. Davis.	Apr., 1882	Edition of 1882.
430*a*	1590	Harbor chart, Bull's Bay, S. C	1-40, 000	3. W. A. Thompson. 4. E. A. Maedel, A. C. Ruebsam.	Aug., 1881	Edition of 1881.
438	1233	Harbor chart, Beaufort River and Inside Passage, &c.	1-40, 000	3, 4. T. Wasserbach	May, 1882	Edition of 1882.
447	1155	Harbor chart, Saint Simon's Sound, Brunswick Harbor, &c.	1-40, 000	3, 4. T. Wasserbach. 4. E. H. Sipe....	Mar., 1882	Edition of 1882.
453	1673	Harbor chart, Fernandina Entrance	1-20, 000	1. H. M. Knight. 2, 3. R. F. Bartle. 4. E. A. Maedel, E. H. Sipe, A. C. Ruebsam.	June, 1882	Edition of 1882.
480	845	Harbor chart, Cedar Keys, Fla	1-50, 000	4. A. C. Ruebsam	Mar., 1882	Reissued.
490	1391	Harbor chart, entrance to Pensacola Bay	1-30, 000	4. T. Wasserbach, A. C. Ruebsam.....	June, 1882	Edition of 1882.
......	1655	Sketch of general progress, east part, Atlantic.	1-5, 000, 000	2, 4. W. A. Thompson, J. G. Thompson. 4. A. Petersen.	Mar., 1882	
......	1618	Progress sketch, east coast of Florida, Indian River to Cape Florida.	1-200, 000	1, 4. W. H. Davis......................	Jan., 1882	
......	1676	Telegraphic longitudes, showing connections adjusted June, 1880.	....	4. W. H. Davis........................	Mar., 1882	
......	1666	Atlantic Coast Pilot chart, entrance to East Penobscot Bay.	1-80, 000	4. E. H. Sipe	Dec., 1881	
......	1663	Atlantic Coast Pilot chart, Castine Harbor.	1-40, 000	4. E. H. Sipe	Sept., 1881	
......	1667	Atlantic Coast Pilot chart, entrance to West Penobscot Bay.	1-80, 000	2, 4. E. H. Sipe	Dec., 1881	
......	1669	Atlantic Coast Pilot chart, Penobscot Bay, northern part.	1-80, 000	2. W. A. Thompson. 4. E. H. Sipe....	Dec., 1881	
......	1661	Atlantic Coast Pilot view, Rockland Harbor.	....	4. W. H. Davis	Sept., 1881	
......	1637	Atlantic Coast Pilot view, Charleston Entrance, &c.	....	4. W. H. Davis........................	Dec., 1881	
......	1657	Atlantic Coast Pilot view, Charleston Harbor, &c.	....	4. W. H. Davis........................	Apr., 1882	
......	1678	Atlantic Coast Pilot view, White House, Potomac River.	....	4. W. H. Davis........................	Feb., 1882	
......	1670	Topographical specimen, Nahant, curves	....	2. H. C. Evans	Dec., 1881	
......	1682	Topographical specimen, Eagle Cliff, curves.	....	2. H. C. Evans	May, 1882	
......	1683	Topographical specimen, Robinson's Mountain, curves.	....	2. H. C. Evans	Apr., 1882	
......	1684	Topographical specimen, Brown's Mountain, curves.	....	2. H. C. Evans	May, 1882	
......	1685	Topographical specimen, Beach Echo Mountain.	....	1, 2, 3. H. C. Evans	May, 1882	
......	1688	Topographical specimen, Harper's Ferry, upper curves.	....	2. H. C. Evans	June, 1882	
		PACIFIC COAST.				
672	1228	General coast chart, Santa Monica to Point Conception.	1-200, 000	2. W. A. Thompson. 3. H. M. Knight. 4. E. A. Maedel.	June, 1882	First edition.
624	877	Harbor chart, Petaluma and Napa Creeks	1-30, 000	1, 3. W. A. Thompson. 4. A. C. Ruebsam.	Mar., 1882	Reissued.
654	1104	Harbor chart, Washington Sound and approaches.	1-200, 000	1, 2. W. A. Thompson. 4. E. H. Sipe..	Aug., 1881	Reissued.
......	1654	Sketch of general progress, west part, Pacific.	1-5, 000, 000	2, 3. W. A. Thompson. 2, 4. J. G. Thompson.	Mar., 1882	
......	1662	Topographical specimen, gulch near Santa Cruz, Cal.	1-10, 000	1, 2, 3. H. C. Evans....	Dec., 1881	

APPENDIX No. 5—Continued.

Catalogue No.	Plate No.	Title of plates.	Scale.	Engravers.	Date of completion.	Remarks.
		COMPLETED.				
		PACIFIC COAST—Continued.				
......	1662[1]	Topographical specimen, gulch near Santa Cruz, Cal., curves.	1-10,000	2. H. C. Evans	Dec., 1881	
......	1671	Topographical specimen, The Dalles, Oreg.	1-10,000	1, 2, 3. Joseph C. Lee..................	Dec., 1881	
......	1672	Topographical specimen, The Dalles, Oreg., curves.	1-10,000	2. Joseph C. Lee	Dec., 1881	
......	1687	Topographical specimen, Cape Disappointment, curves.	1-10,000	2. H. C. Evans	June, 1882	
		CONTINUED.				
11	1429	General coast chart No. 6, Cape Hatteras to Cape Romain.	1-400,000	1, 2, 3. W. A. Thompson. 4. J. G. Thompson.	....	
13	1456	General coast chart No. 8, Saint Mary's, entrance to Cape Canaveral.	1-400,000	3. W. A. Thompson. 4. E. A. Maedel, A. Petersen.	....	
21	1090	General coast chart No. 16, Galveston to the Rio Grande.	1-400,000	1. W. A. Thompson. 4. A. Petersen..	....	
103	1113	Coast chart No. 3, Frenchman's and Blue Hill Bays.	1-80,000	2. W. A. Thompson. 3. H. M. Knight. 4. E. A. Maedel, J. G. Thompson, F. Courtenay.	....	
142	1272	Coast chart No. 42, Pamplico Sound, Roanoke Island to Hateras Inlet.	1-80,000	2. W. A. Thompson. 3. F. W. Benner. 4. E. A. Maedel, James Loughren.	....	
143	1190	Coast chart No. 43, Pamplico Sound, Ocracoke Inlet to mouth of Pamplico River.	1-80,000	3. F. W. Benner. 4. E. A. Maedel, A. C. Ruebsam.	....	
153	1503	Coast chart No. 53, Winyah Bay to Long Island.	1-80,000	2. A. Sengteller. 4. F. Courtenay....	....	
158	1234	Coast chart No. 58, from Saint Mary's Entrance southward, latitude 30° north.	1-80,000	2, 3. W. A. Thompson. 4. E. A. Maedel, A. Petersen, A. C. Ruebsam.	....	
159	1411	Coast chart No. 59, Saint Augustine Inlet to Halifax River.	1-80,000	2. W. A. Thompson. 4. A. Petersen..	....	
161	1602	Coast chart No. 61, Mosquito Lagoon to Cape Canaveral.	1-80,000	4. William B. Cragg, E. H. Sipe	....	
175	1093	Coast chart No. 75, Charlotte Harbor...	1-80,000	1, 2. W. A. Thompson. 4. A. Petersen.	....	
181	1450	Coast chart No. 81, Apalachee Bay	1-80,000	4. E. A. Maedel, W. H. Davis........	....	
182	1447	Coast chart No. 82, Apalachee Bay and Saint George's Sound.	1-80,000	1, 2. W. A. Thompson. 4. A. C. Ruebsam.	....	
184	1601	Coast chart No. 84, Saint Joseph's Bay to Saint Andrew's Bay.	1-80,000	4. F. Courtenay	....	
185	1498	Coast chart No. 85, Saint Andrew's Bay to Choctawhatchee Gulch.	1-80,000	4. E. H. Sipe	....	
192	1537	Coast chart No. 92, Chandeleur and Isle Breton Sounds.	1-80,000	3. H. M. Knight........................	....	
195	1314	Coast chart No. 95, Mississippi River, from the forts to New Orleans.	1-80,000	2. A. Sengteller	....	
204	1316	Coast chart No. 104, Galveston Bay	1-80,000	3. F. W. Benner. 4. E. A. Maedel	....	
209	1248	Coast chart No. 109, Aransas Pass, Aransas and Copano Bays.	1-80,000	3. F. W. Benner........................	....	
306	1186	Harbor chart, Frenchman's Bay and Somes Sound.	1-40,000	1, 2. W. A. Thompson, R. F. Bartle. 3. H. C. Evans. 4. A. Petersen, E. H. Sipe.	....	
307	1265	Harbor chart, Blue Hill and Union River Bays.	1-40,000	1, 2, 3. H. C. Evans. 2. W. A. Thompson. 4. A. Petersen, J. G. Thompson.	....	
308	1376	Harbor chart, approaches to Blue Hill Bay, &c.	1-40,000	1, 4. J. G. Thompson. 2. R. F. Bartle..	....	
621a	1532	Harbor chart, San Francisco Bay, entrance.	1-40,000	2, 3. H. M. Knight. 4. E. A. Maedel, A. Petersen.	....	

APPENDIX No. 5—Continued.

Catalogue No.	Plate No.	Title of plates.	Scale.	Engravers.	Date of completion.	Remarks.
		CONTINUED.				
		PACIFIC COAST—Continued.				
641b	1533	Harbor chart, Columbia River No. 4	1-40, 000	2. R. F. Bartle. 4. E. A. Maedel, A. Petersen.	....	
		COMMENCED.				
D	1653	Sailing chart, Gulf of Mexico............	1-2, 100, 000	1. J. G. Thompson	....	
292	1686	Harbor chart, Mount Desert Island	1-40, 000	1, 2. W. A. Thompson. 4. J. G. Thompson.	....	
402a	1664	Harbor chart, James River No. 4, City Point to Kingsland Creek.	1-20, 000	1, 2. J. Enthoffer. 3. H. M. Knight. 4. A. Petersen.	....	
402b	1679	Harbor chart, James River No. 5, Kingsland Creek to Richmond.	1-20, 000	1, 2. J. Enthoffer. 4. A. C. Ruebsam..	....	
......	1666	Atlantic Coast Pilot chart, entrance to East Penobscot Bay.	1-80, 000	4. E. H. Sipe	....	
......	1663	Atlantic Coast Pilot chart, Castine Harbor.	1-40, 000	4. E. H. Sipe	....	
......	1667	Atlantic Coast Pilot chart, entrance to West Penobscot Bay.	1-80, 000	2, 4. E. H. Sipe	....	
......	1669	Atlantic Coast Pilot chart, Penobscot Bay, northern part.	1-80, 000	2. W. A. Thompson. 4. E. H. Sipe....	....	
......	1661	Atlantic Coast Pilot view, Rockland Harbor.	....	4. W. H. Davis	....	
......	1678	Atlantic Coast Pilot view, White House, Potomac River.	....	4. W. H. Davis........................	....	
......	1670	Topographical specimen, Nahant, curves	....	2. H. C. Evans	....	
......	1682	Topographical specimen, Eagle Cliff, curves.	....	2. H. C. Evans	....	
......	1683	Topographical specimen, Robinson's Mountain, curves.	....	2. H. C. Evans	....	
......	1684	Topographical specimen, Brown's Mountain, curves.	....	2. H. C. Evans	....	
......	1685	Topographical specimen, Beach Echo Mountain.	....	1, 2, 3. H. C. Evans	....	
......	1688	Topographical specimen, Harper's Ferry, upper curves.	....	2. H. C. Evans	....	
......	1676	Telegraphic longitudes, diagrams showing connections, adjusted June, 1880.	....	4. W. H. Davis........................		
......	1662	Topographical specimen, gulch near Santa Cruz, Cal.	....	1, 2, 3. H. C. Evans	....	
......	1662[1]	Topographical specimen, gulch near Santa Cruz, Cal., curves.	....	2. H. C. Evans	....	
......	1671	Topographical specimen, The Dalles, Oreg.	....	1, 2, 3. Joseph C. Lee	....	
......	1672	Topographical specimen, The Dalles, Oreg., curves.	....	2. Joseph C. Lee	....	
......	1687	Topographical specimen, Cape Disappointment, curves.	....	2. H. C. Evans	....	
......	1690	Topographical specimen, view between Fallen Leaf and Little Truckee Valley, Cal.	....	J. R. Barker........................	....	
......	1691	Topographical specimen, view of the Dalles, Oreg.	....	J. R. Barker........................	....	
......	1665	Alaska Coast Pilot view, Point Rose, North Point, &c.	....	J. R. Barker........................	....	

APPENDIX No. 5—Continued.

Standard printing plates having received additions and corrections from July 1, 1881, to June 30, 1882.

Catalogue No.	Plate No.	Title of plates.	Scale.	Date of last correction.	Aids to navigation corrected to—
		SAILING CHARTS, ATLANTIC COAST.			
A	1357	Sailing chart A, Cape Sable to Cape Hatteras, upper	1-1, 200, 000	May 10, 1882	1882.
A	1367	Sailing chart A, Cape Sable to Cape Hatteras, lower	1-1, 200, 000	May 10, 1882	1882.
B	1642	Sailing chart B, Cape Hatteras to Key West, upper	1-1, 200, 000	June, 1882	1882.
B	1643	Sailing chart B, Cape Hatteras to Key West, lower	1-1, 200, 000	June, 1882	1882.
5	1453	Sailing chart No. 5, Key West to the Rio Grande, east	1-1, 200, 000	Mar., 1882	1882.
5	1451	Sailing chart No. 5, Key West to the Rio Grande, west	1-1, 200, 000	Mar., 1882	1882.
C	1453	Sailing chart C, Gulf of Mexico, east	1-1, 200, 000	Jan., 1882	1881.
C	1517	Sailing chart C, Gulf of Mexico, west	1-1, 200, 000	Jan., 1882	1881.
C	1600	Sailing chart C, Gulf of Mexico, west	1-1, 200, 000	Jan., 1882	1881.
C	1598	Sailing chart C, Gulf of Mexico, east	1-1, 200, 000	Jan., 1882	1881.
		GENERAL COAST CHARTS, ATLANTIC COAST.			
6*a*	1635	General coast chart No. 1, Isle au Haut to Cape Cod, west	1-400, 000	July, 1881	1881.
7	1242	General coast chart No. 2, Cape Ann to Gay Head	1-400, 000	Aug., 1881	1880.
8	1392	General coast chart No. 3, Gay Head to Cape Henlopen	1-400, 000	Oct., 1881	1881.
9	1183	General coast chart No. 4, Cape May to Cape Henry	1-400, 000	May, 1882	1882.
12	1350	General coast chart No. 7, Cape Romain to Saint Mary's entrance	1-400, 000	Dec., 1881	1881.
15	1081	General coast chart No. 10, Straits of Florida	1-400, 000	Apr., 1882	1881.
		COAST CHARTS, ATLANTIC COAST.			
104	1658	Coast chart No. 4, Penobscot Bay	1-80, 000	June, 1882	1882.
105	1249	Coast chart No. 5, Penobscot Bay to Kennebec entrance	1-80, 000	June, 1882	1881.
107	1271	Coast chart No. 7, Seguin Island to Kennebunkport	1-80, 000	May, 1882	1882.
108	1201	Coast chart No. 8, Wells to Cape Ann	1-80, 000	May, 1882	1882.
109	1181	Coast chart No. 9, Boston Harbor and approaches	1-80, 000	Apr., 1882	1882.
111	1402	Coast chart No. 11, Monomoy and Nantucket Shoals, &c	1-80, 000	May, 1882	1882.
112	1054	Coast chart No. 12, Muskeget Channel to Buzzard's Bay	1-80, 000	Apr., 1882	1882.
113	1677	Coast chart No. 13, Cuttyhunk to Block Island, &c	1-80, 000	June, 1882	1882.
114	1363	Coast chart No. 14, Point Judith and Block Island to Plum Island	1-80, 000	May, 1882	1882.
115	1419	Coast chart No. 15, Plum Island to Welch's Point	1-80, 000	June, 1882	1882.
116	1473	Coast chart No. 16, Welch's Point to New York	1-80, 000	May, 1882	1882.
119	866	Coast chart No. 19, Great South Bay, Fire Island, &c	1-80, 000	Oct., 1881	1878.
120	1404	Coast chart No. 20, New York Bay and Harbor	1-80, 000	June, 1882	1882.
121	1535	Coast chart No. 21, Sandy Hook to Barnegat Inlet	1-80, 000	Jan., 1882	1882.
122	1536	Coast chart No. 22, Barnegat Inlet to Absecon Inlet	1-80, 000	July, 1881	1879.
124	1610	Coast chart No. 24, Delaware entrance	1-80, 000	Apr., 1882	1882.
125	1611	Coast chart No. 25, part of Delaware Bay and River	1-80, 000	Nov., 1881	1881.
126	1614	Coast chart No. 26, Delaware River, Port Penn to Trenton	1-80, 000	May, 1882	1882.
127	1200	Coast chart No. 27, Cape May to Isle of Wight	1-80, 000	Nov. 1881	1880.
128	1230	Coast chart No. 28, Isle of Wight to Chincoteague Inlet	1-80, 000	June, 1882	1882.
129	1286	Coast chart No. 29, Chincoteague Inlet to Hog Island	1-80, 000	June, 1882	1880.
131	1219	Coast chart No. 31, entrance to Chesapeake, Hampton Roads, &c	1-80, 000	Feb., 1882	1882.
132	1211	Coast chart No. 32, York River to Pocamoke Sound	1-80, 000	May, 1882	1881.
133	1222	Coast chart No. 33, Pocomoke Sound to Potomac River	1-80, 000	Sept., 1881	1880.
134	1227	Coast chart No 34, Potomac River to Choptank River	1-80, 000	Dec., 1881	1881.
136	1265	Coast chart No. 36, Magothy River to Head of Bay	1-80, 000	June, 1882	1881.
138	1435	Coast chart No. 38, Currituck Beach to Oregon Inlet	1-80, 000	Jan., 1882	1882.
139	1675	Coast chart No. 39, Oregon Inlet to Cape Hatteras	1-80, 000	Jan., 1882	1882.
140	890	Coast chart No. 40, Atlantic Ocean to Pasquotank River	1-80, 000	....	......
154	1176	Coast chart No. 54, Long Island to Hunting Island	1-80, 000	Nov., 1881	1881.
155	1358	Coast chart No. 55, Hunting Island to Ossabaw Island	1-80, 000	Jan., 1882	1881.
156	1341	Coast chart No. 56, Savannah River to Sapelo Island	1-80, 000	July, 1881	1881.
157	1346	Coast chart No. 57, Sapelo Island to Amelia Island	1-80, 000	Apr., 1882	1882.
166	884	Coast chart No. 66, Key Biscayne to Carysfort Reef	1-80, 000	Mar., 1882	1881.
168	1100	Coast chart No. 68, Long Key to Newfound Harbor Key	1-80, 000	July, 1881	1881.
183	1681	Coast chart No. 83, Apalachicola Bay to Cape San Blas	1-80 000	Apr., 1882	1882.
188	1158	Coast chart No. 88, Mobile Bay, Ala	1-80, 000	Dec., 1881	1881.
189	842	Coast chart No. 89, Bon Secours Bay to Round Island	1-80, 000	Apr., 1882	1881.
190	1052	Coast chart No. 90, Round Island to Saint Joseph's Island	1-80, 000	June, 1882	1882.

APPENDIX No. 5—Continued.

Catalogue No.	Plate No.	Title of plates.	Scale.	Date of last correction.		Aids to navigation corrected to—
194	1280	Coast chart No. 94, Mississippi River, from the Passes to New Orleans	1-80, 000	June,	1882	1882.
304a	1203	Harbor chart, Moose à Bec-Reach	1-40, 000	Sept.,	1881	1881.
311a	1128	Harbor chart, Fox Islands Thoroughfare	1-20, 000	July,	1881	1881.
313	1261	Harbor chart, Damariscotta and Medomak Rivers	1-40, 000	Feb.,	1882	1881.
314	1112	Harbor chart, Kennebec and Sheepscot Rivers	1-40, 000	Mar.,	1882	1881.
315	1204	Harbor chart, Casco Bay	1-40, 000	June,	1882	1882.
321	1015	Harbor chart, Camden and Rockport Harbors	1-20, 000	Nov.,	1881	1881.
325	1174	Harbor chart, Portland Harbor	1-20, 000	Jan.,	1882	1882.
329	1379	Harbor chart, Portsmouth Harbor	1-20, 000	Jan.,	1882	1882.
334	850	Harbor chart, Gloucester Harbor	1-20, 000	June,	1882	1882.
335	1328	Harbor chart, Salem Harbor	1-25, 000	Mar.,	1882	1882.
337	1184	Harbor chart, Boston Harbor	1-40, 000	June,	1882	1882.
338	1326	Harbor chart, Plymouth, Kingston, and Duxbury Harbors	1, 40, 000	Feb.,	1882	1882.
340	878	Harbor chart, Barnstable Harbor	1-20, 000	May,	1882	1882.
345	860	Harbor chart, Muskeget Channel	1-60, 000	Apr.,	1882	1882.
348	779	Harbor chart, Wood's Hole Harbor	1-20, 000	Jan.,	1882	1882.
350	1344	Harbor chart, New Bedford Harbor	1-40, 000	Jan.,	1882	1882.
353	1241	Harbor chart, Narragansett Bay, upper	1-40, 000	Nov.,	1881	1881.
353	1240	Harbor chart, Narragansett Bay, lower	1-40, 000	Nov.,	1881	1881.
359	849	Harbor chart, New London Harbor	1-20, 000	Nov.,	1881	1881.
360	1544	Harbor chart, Mouth of Connecticut River	1-20, 000	June,	1882	1882.
361	1274	Harbor chart, Hart and City Islands, &c	1-20, 000	Mar.,	1882	1882.
367	162	Harbor chart, Oyster or Syosset Bay	1-30, 000	Jan.,	1882	1882.
369	1268	Harbor chart, New York Bay and Harbor, upper	1-40, 000	June,	1882	1882.
369	1266	Harbor chart, New York Bay and Harbor, lower	1-40, 000	June,	1882	1882.
369a	1304	Harbor chart, New York entrance	1-40, 000	May,	1882	1882.
370	1034	Harbor chart, Hudson River, New York to Haverstraw	1-60, 000	June,	1882	1882.
376	453	Harbor chart, Delaware and Chesapeake Bays	1-400, 000	May,	1882	1882.
383	1275	Harbor chart, Mouth of Chester River	1-40, 000	Feb.,	1882	1881.
384	1620	Harbor chart, Patapsco River and Baltimore Harbor	1-60, 000	Apr.,	1882	1882.
385	1452	Harbor chart, Annapolis Harbor	1-60, 000	Jan.,	1882	1882.
386	784	Harbor chart, Patuxent River, Md	1-60, 000	June,	1882	1882.
388	1135	Harbor chart, Potomac River No. 1, entrance up to Piney Point	1, 60, 000	May,	1882	1881.
389	1171	Harbor chart, Potomac River No. 2, Piney Point to Lower Cedar Point	1, 60, 000	May,	1882	1881.
390	1148	Harbor chart, Potomac River No. 3, Lower Cedar Point to Indian Head	1-60, 000	May,	1882	1881.
391	1319	Harbor chart, Potomac River No. 4, Indian Head to Georgetown	1, 40, 000	Nov.,	1881	1881.
398	987	Harbor chart, York River, sheet 1, entrance to King's Creek	1-60, 000	Oct.,	1881	1881.
399	775	Harbor chart, York River, sheet 2, King's Creek to West Point	1-60, 000	Oct.,	1881	1881.
403	953	Harbor chart, Hampton Roads and Elizabeth River	1-40, 000	Dec.,	1881	1881.
410	1105	Harbor chart, port of New Berne	1-40, 000	Jan.,	1882	1882.
419	1023	Harbor chart, Cape Lookout Shoals	1-80, 000	June,	1882	1882.
422	375	Harbor chart, New River and Bar	1-15, 000	June,	1882	1882.
431	1192	Harbor chart, Charleston Harbor	1-30, 000	Jan.,	1882	1881.
434	868	Harbor chart, North Edisto River	1-50, 000	July,	1881	1881.
436	1140	Harbor chart, Saint Helena Sound	1-40, 000	Feb.,	1882	1881.
437	1329	Harbor chart, Whale Branch, inside passage between Coosaw and Broad Rivers	1, 40, 000	Jan.,	1882	1882.
440	1070	Harbor chart, Savannah River and Wassaw Sound	1-40, 000	Sept.,	1881	1881.
441	948	Harbor chart, Ossabaw Sound	1-30, 000	Apr.,	1882	1882.
443	1295	Harbor chart, Saint Catharine's Sound	1, 40, 000	Oct.,	1881	1881.
444	946	Harbor chart, Sapelo Sound	1-30, 000	Mar.,	1882	1882.
446	1312	Harbor chart, Doboy and Altamaha Sounds	1-40, 000	June,	1882	1882.
448	1298	Harbor chart, Saint Andrew's Sound	1-40, 000	Oct.,	1881	1881.
453	1288	Harbor chart, Saint Mary's River and Fernandina Harbor	1-20, 000	Apr.,	1882	1881.
454	663	Harbor chart, Saint John's River No. 1, entrance to Brown's Creek	1-25, 000	May,	1882	18 2.
455	991	Harbor chart, Saint John's River No. 2, Brown's Creek to Jacksonville	1-25, 000	May,	1882	1882.
471a	1475	Harbor chart, Tortugas Harbor and approaches	1-40, 000	Nov.,	1881	1880.
477	1400	Harbor chart, entrance to Tampa Bay	1-40, 000	Jan,	1882	1881.
520	1149	Harbor chart, Galveston entrance, Texas	1-40, 000	Nov.,	1881	1880.
553	1489	Harbor chart, Lake Champlain No. 1, Rouse's Point to Cumberland Head	1-50, 000	Feb.,	1882	1882.
554	1501	Harbor chart, Lake Champlain No. 2, Cumberland Head to Ligonier Point	1-50, 000	Feb.,	1882	1882.
555	1336	Harbor chart, Lake Champlain No. 3, Ligonier Point to Cole's Bay	1-50, 000	Feb.,	1882	1882.
556	1337	Harbor chart, Lake Champlain No. 4, Cole's Bay to Whitehall	1-50, 000	Feb.,	1882	1882.

APPENDIX No. 5—Continued.

Catalogue No.	Plate No.	Title of plates.	Scale.	Date of last correction.		Aids to navigation corrected to—
601	1036	Sailing chart, San Diego to San Francisco	1-1, 200, 000	Feb.,	1882	1880.
602	435	Sailing chart, San Francisco to Umpquah River	1-1, 200, 000	May,	1882	1882.
603	650	Sailing chart, Umpquah River to Northwestern boundary	1-1, 200, 000	Apr.,	1882	1882.
675	1064	General coast chart, Point Pinos to Bodega Head	1-200, 000	Feb.,	1882	1882.
620	1142	Harbor chart, Half-Moon Bay	1-20, 000	Sept.,	1881	1879.
621	818	Harbor chart, entrance to San Francisco Bay	1-50, 000	Mar.,	1882	1881.
622	1074	Harbor chart, San Francisco Bay, upper	1-50, 000	Feb.,	1882	1882.
623	1006	Harbor chart, San Pablo Bay	1-50, 000	Mar.,	1882	1882.
624	877	Harbor chart, Petaluma and Napa Creeks	1-30, 000	Mar.,	1882	1882.
628	1179	Harbor chart, San Francisco Peninsula	1-40, 000	Sept.,	1881	1881.
633	1264	Harbor chart, Trinidad Harbor	1-15, 000	Mar.,	1882	1882.
637	1107	Harbor chart, Koos Bay, Oregon	1-30, 000	Feb.,	1882	1882.
640	1245	Harbor chart, Columbia River No. 4	1, 40, 000	Dec.,	1881	1878.
654	1104	Harbor chart, Washington Sound and approaches	1-200, 000	June,	1882	1880.
662	1144	Harbor chart, Puget Sound	1-200, 000	Oct.,	1881	1880.
		PROGRESS SKETCHES.				
......	1655	Sketch of general progress, eastern sheet, Atlantic	1-5, 000, 000	May,	1882	1879.
......	1654	Sketch of general progress, western sheet, Pacific	1-5, 000, 000	May,	1882	1879.
......	53	Progress sketch showing the survey in Section 1	1-400, 000	Jan.,	1882	1879.
....	1055	Primary triangulation between Long Island and the Blue Ridge	1-1, 000, 000	Dec.,	1881	1879.
......	1650	Primary triangulation between the Maryland and Georgia base lines	1-1, 000, 000	Aug.,	1881	1879.
......	1359	Progress sketch, Section 6, east coast of Florida, Halifax River to Cape Canaveral	1-200, 000	Jan.,	1882	1879.
......	1618	Progress sketch, Section 6, east coast of Florida, Indian River to Cape Florida	1-200, 000	June,	1882	1881.
......	1269	Progress sketch, Section 6, west coast of Florida, Tampa Bay, and vicinity	1-200, 000	June,	1882	1881.
......	567	Sketch showing the progress of the survey in Section 8, Alabama, Mississippi, and Louisiana.	1-600, 000	Feb.,	1882	1879.
......	568	Sketch showing the progress of the survey in Section 9, Texas	1-600, 000	Jan.,	1882	1879.
......	569	Sketch showing the progress of the survey in Section 10, from San Diego to Point Sal	1-600, 000	Feb.,	1882	1879.
......	1368	Geodetic connection of the Atlantic and Pacific coast triangulation, Missouri and Illinois.	1-400, 000	Jan.,	1882	1879.

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APPENDIX No. 6.

OFFICE REPORTS.

REPORTS OF THE CHIEFS OF DIVISIONS AND OTHERS, OFFICE OF THE UNITED STATES COAST AND GEODETIC SURVEY, FOR THE FISCAL YEAR ENDING JUNE 30, 1882.

COMPUTING DIVISION, *June* 30, 1882.

DEAR SIR: In conformity with regulations, I herewith respectfully submit the usual annual report of work done by the several computers during the fiscal year ending June 30, 1882.

The charge of the Computing Division has been continued with me and no important alteration in its management was made. The computations in connection with the Mississippi River triangulations and the lines of spirit-levels still pressed heavily on the available computing force, which was further weakened by the death of Dr. Gottlieb Rumpf who had been uninterruptedly connected with the Computing Division since 1849. He was born at Basle, Switzerland, May 5, 1812, and joined the Computing Division April 1, 1849, since which time he discharged his official duties most faithfully and conscientiously. On January 19 he was seized with a fatal illness, to which he succumbed February 20, 1882. In consequence of his intimate acquaintance with the triangulation work, and his long service and experience in the division, his loss will long be felt. Mr. H. Farquhar was temporarily detached and assigned to field duty from February 28 to May 8, 1882. Temporary assistance to the Computing Division was given by C. B. Turnbull, copyist, to December 15, 1881; by F. Gilman, between August 1 and October 31, 1881; by T. P. Borden, Aid, between November 17 and December 12, 1881, and again between January 23 and May 1, 1882; by I. Winston, Aid, between December 3 and December 29, 1881, and again from May 11 to the close of the fiscal year; by D. B. Wainwright, Subassistant, between January 9 and February 20, and again between March 2 and June 6, 1882; by J. E. McGrath, Aid, between January 20 and March 8, 1882; by W. B. Fairfield, between January 25 and June 6, 1882.

The observations which had been made for determining the length of the two five-meter standards, and the length of the new base-bars, as mentioned in my last year's report, were computed and discussed by me before starting for California. In accordance with instructions from the late Superintendent, dated July 8, 1881, I left Washington August 19, and assisted in the measure of the Yolo base, Cal., and after attending to some other matter required by the instructions, returned to the office October 15, 1881. During my absence Mr. E. H. Courtenay took charge of the Computing Division. Two more sets of comparisons for the length of the new five-meter standard were made and computed. With the assistance of Mr. Suess and Mr. Porter I determined the coefficient of expansion and length of a meter rod belonging to the Signal Corps service. The supply of the pamphlet on the determination of time, latitude, and azimuth having been exhausted I brought out a new (the third) edition, revised and enlarged, including the subject of telegraphic longitudes; the plates illustrating the same are for the greater part new. I also prepared the manuscript for a new (the third) edition of my paper on measurement of terrestrial magnetism. In this edition the subject-matter is differently arranged from what it was; it has also been enlarged. I have also collected, revised, and arranged, by States and Territories, and for each in chronological order, all the magnetic results from observations made by the Coast and Geodetic Survey between 1833 and July, 1882, comprising declinations, dips, and intensities at more than 600 different stations, giving also the individual results when occupied more than once; the intensities are given in British units as well as in Coast and Geodetic Survey units; descriptions of stations accompany the paper. Early in May, 1882, two observers were instructed in the use of the sextant and of magnetic instruments for absolute measure. In this work I had the assistance of Mr. M. Baker. One of the observers was destined for the United States Signal Corps station at Lady Franklin Bay, North Greenland; the other for a similar station at Point Barrow, Alaska. The Brooke magnetographs, which had been at work for some years at Madison, Wis., were dismounted and brought to Washington in December 1881, the Superintendent having thought it expedient to terminate the magnetic observations at that place. These instruments were altered and newly fitted for differential observations to be made at the Signal Corps station at Point Barrow, and by June 14, 1882, they had been completed and packed, and the observer was instructed, with the aid of Assistant Eimbeck, to use them at the Alaska station in conformity and in co-operation with the International Polar Conference. A general collection of results for magnetic declinations within the United States and close to its borders has been made by me, comprising over 2,200 stations; these results will be utilized hereafter for the construction of a new magnetic chart. The usual annual magnetic observations were made on three days at the magnetic observatory in this city in June, 1882, this time by Assistant Eimbeck.

The usual office correspondence, the demands from the Engraving Division for information, geodetic, astronomical, and magnetic, for charts, and from the Drawing Division for geographical positions, and the Hydrographic Division for descriptions of geodetic stations, were all promptly attended to.

From the following statements, giving the work done, in detail, of every computer during the fiscal year, it will be seen that the general distribution of the various classes of work was about the same as last year.

Dr. Gottlieb Rumpf computed the following secondary and tertiary triangulations: Columbia River, south and east of Kalama, W. T., 1878; Indian River, Fla., 1880–'81; Cape May, N. J., 1881; revised and computed geographical positions on Clarke's spheroid of the triangulations of Columbia River, Oreg. and W. T., 1852–'77, of Shoalwater Bay, W. T., 1871–'72–'73, of the triangulation south of entrance of Columbia River, Oregon, and of the triangulation between Fire Island and New York Bay, N. Y. He also computed positions of some stations in New Jersey, Pennsylvania, New Hampshire, and Great South Bay, Long Island, N. Y.

Mr. Edward H. Courtenay attended to the insertion of the resulting geographical positions in the office registers for use of the computers and daughtsmen; revised the magnetic constants for several magnetometers, revised the computations for magnetic intensity determined by these magnetometers; assisted in the preparation of the annual statistics; adjusted the triangulation of Cape Fear River, N. C., adjusted the old and new triangulations on Delaware River and Bay, 1840–'41–'42, and 1875–'79–'81; instructed and supervised the work done by several of the temporary computers, and had charge of the Computing Division during my absence on the Western coast.

Mr. Myrick H. Doolittle computed and adjusted the triangulation on the Mississippi River from Lake Providence, La., to Walnut Point, Miss., 1880–'81, and thence to Greenville, Miss., 1880–'81; assisted in the preparation of the annual geodetic statistics and computed the supplementary triangulation of the District of Columbia, 1880–'81; prepared abstracts of directions of primary triangulation in New York and Vermont, 1880, and connected the new and the old Lake Champlain triangulations; revised and based on Clarke's spheroid the coast triangulation (main series) from Charleston, S. C., to the North Carolina boundary line 1853 to 1873, and from Ossabaw, Ga., southward as far as Saint John's River, Fla.

Dr. Jermain G. Porter computed the triangulation of San Simeon Bay, Cal., 1871–'72–'73–'74; revised computation of old secondary triangulation on the Delaware River and upper Chesapeake Bay, basing it on the revised primary work and on Clarke's spheroid; computed the subsidiary triangulation in the vicinity of San Francisco, 1877; revised the astronomical azimuth computation East base, Colo., 1879, and computed the horizontal directions at primary stations Southeast base, Yolo, Cal., 1880, at Northwest base, Yolo, Cal., 1880, and at Monticello, Cal., 1880; assisted me in checking computations and in observations in connection with the standarding of the new five-meter bar, and in the preparation for publication of the magnetic results of the Survey; computed the magnetic observations made by Lieutenant-Commander Nichols between San Francisco and Sitka, 1881; computed the magnetic observations made by Subassistant Baylor in the Southern States in 1881; computed Assistant Eimbeck's magnetic observations in California, Nevada, and Utah, 1881; computed Lieutenant Very's magnetic observations in Nova Scotia, Newfoundland, and Labrador, 1881; computed the observations for magnetic declinations taken by Assistant Lawson in California, Oregon, Washington Territory, and Idaho, 1881; revised the computations of the magnetic observations made by Mr. Poole in 1875, and attended to some miscellaneous revisions.

Mr. Alexander S. Christie prepared mean places of stars for field parties; revised the computation for spirit-level heights on line between Hagerstown, Md., and Bloomington, Md.; computed the height from spirit-levels of line between Bloomington, Md., and Athens, Ohio, 1879; computed the astronomical latitudes of Vaca, Cal., 1880, and of Southeast Yolo base, Cal., 1880; computed the astronomical azimuths of East base, Colo., 1879, and of Southeast Yolo base Cal., 1880; and nearly completed the azimuth computation of Northwest Yolo base, Cal., 1880.

Mr. Charles H. Kumnell computed the telegraphic difference of longitude between Nashville, Tenn., and Atlanta, Ga., 1879–'80; between Nashville, Tenn., and New Orleans, La., 1880; between Nashville, Tenn., and Washington, D. C., 1877; and nearly completed the computation for difference of longitude, Nashville, Tenn., and Columbus, Ohio, 1877.

Mr. Henry Farquhar computed the magnetic observations, made by Lieutenant-Commander Nichols in California and in Mexico, 1880–'81; computed height from spirit-levels on line between Athens, Ohio, and Mitchell, Ind., 1879; computed the astronomical latitude of Northwest Yolo base, Cal., 1880; revised computations of Lieutenant Very's magnetic work of 1881, and nearly completed the revision of the office computation of Assistant Lawson's magnetic work of 1881.

Mr. C. W. Henderson attended to the clerical duties of the Computing Division, chiefly furnishing descriptions of stations to field parties and entering geographical positions in the registers.

The following is a specification of the work done by computers temporarily attached to the Computing Division:

Sub-assistant D. B. Wainwright assisted in the revision of the computation of the Cape Fear River triangulation; computed geographical positions in the vicinity of New York City, Coney Island, and Sandy Hook, and of Long Island triangulation, Sullivan, 1874–'75; assisted Mr. Christie and Mr. Doolittle, and made some miscellaneous revision and computation of geographical positions.

T. P. Borden, Aid, was engaged in computing geographical positions, coast of New Jersey, and on the Columbia River, near Portland, Oreg., 1881; assisted Mr. Porter in checking certain geodetic computations in connection with the Yolo base quadrilateral; attended to some copying and other miscellaneous matter.

I. Winston, Aid, revised the horizontal angles of the main triangulation, Hudson River near West Point, and computed geographical positions on the Delaware River and Bay, and in New Jersey.

J. E. McGrath, Aid, computed part of the triangulation executed by Assistant Donn, near New York, 1878, and assisted as recorder in certain comparisons of length under my direction.

F. Gilman prepared abstracts of horizontal directions of the primary triangulation of Illinois, 1880.

C. B. Turnbull attended to some miscellaneous copying.

Yours, very respectfully,

CHAS. A. SCHOTT,
Assistant, Coast and Geodetic Survey, in charge Computing Division.

RICHARD D. CUTTS,
Assistant in charge of Office and Topography.

OFFICE OF THE HYDROGRAPHIC INSPECTOR,
September 23, 1882.

SIR: I have the honor to submit the following report of the Hydrography under my charge for the fiscal year ending June 30, 1882:

The commencement of the year found the following vessels in the field for hydrographic surveying: The steamer Blake, Commander J. K. Bartlett, U. S. N., Assistant, Coast and Geodetic Survey, commanding, on deep-sea sounding in the Gulf Stream; the steamer A. D. Bache, Lieutenant-Commander E. B. Thomas, U. S. N., Assistant, Coast and Geodetic Survey, commanding, preparing for a survey of the entrance to New York Harbor; the steamer Gedney, Lieut. U. Sebree, U. S. N., Assistant, Coast and Geodetic Survey, commanding, just concluding the hydrography off the coast of Texas and on her way to Pensacola, Fla., where she was preparing for the winter season; the steamer Endeavor, Lieut. Henry B. Mansfield, U. S. N., Assistant, Coast and Geodetic Survey, commanding, on the survey of the Delaware River; schooner Eagre, Lieut. H. G. O. Colby, U. S. N., Assistant, Coast and Geodetic Survey, commanding, on the coast of Maine; schooner Ready, Assistant H. L. Marindin, commanding, on the survey of Delaware River.

These vessels, working in the localities mentioned as long as the weather would permit, or to about November 1, 1881, were in most cases—owing to the exhausted condition of the appropriations—by your orders withdrawn from active operations; but, in anticipation of the action of Congress in appropriating money in a deficiency bill for the continuation of the work, were, with partial crews, kept ready to commence operations at short notice.

During the winter season the party on board the steamer Bache, however, was occupied in making an inexpensive hydrographic survey by means of a steam-launch borrowed from the Navy, of the harbor of Norfolk, and in the spring a survey off the east coast of Florida; the steamer Gedney also, at the same time, surveying Pensacola Bay and the harbor of Key West, Fla.; and in making examination of reported changes near Beaufort, S. C., near Georgetown, S. C., and another off Cape Fear, N. C.

In addition to these two parties working during the winter, the schooner Research, in charge of Assistant F. W. Perkins; the Steadfast, in charge of Assistant C. H. Boyd, and the Quick, in charge of Subassistant Joseph Hergesheimer, were fitted out about January 1, 1882, to complete necessary triangulation for future hydrographic work on the coast of Texas, east coast of Florida, and west coast of Florida respectively.

The other vessels belonging to the service were laid up at the places mentioned in my last annual report.

The charge of the party on board the steamer Endeavor, owing to the detachment of Lieut. U. Sebree, U. S. N., from the survey by the Navy Department, he having completed most ably the usual term of three years, was placed under Lieutenant-Commander W. H. Bronson, U. S. N., who had been assigned to the Survey by the Navy Department in September, 1881.

With this exception, the chiefs of hydrographic parties have remained as at the commencement of the year.

On the Pacific coast the steamer Hassler, Lieutenant-Commander H. E. Nichols, Assistant, Coast and Geodetic Survey, commanding, with the party on board until December 1, 1881, was occupied—in addition to magnetic work—in making preliminary surveys and examinations in the waters of Alaska; while the steamer McArthur, Lieut. W. T. Swinburne, U. S. N., Assistant, Coast and Geodetic Survey, commanding, and the schooner Earnest, Lieut. Perry Garst, U. S. N., Assistant, Coast and Geodetic Survey, commanding, were surveying respectively the coast of California and Puget Sound, Oreg.

These vessels were then prepared for the continuation of the hydrography on the Pacific coast, as mentioned for those on the Atlantic coast, for which they were, with the exception of the Hassler, not required. This last vessel was, under instructions of the Superintendent, dispatched to the coast of Alaska, continuing a rapid survey of portions of its coast.

A list of officers of the Navy on duty in the Coast and Geodetic Survey during the fiscal year ending June 30, 1882, is appended to this report.

Repairs of vessels.—In addition to the many incidental items required in keeping in commission a portion, and, from rapid deterioration, the remainder laid up, of a fleet of twenty-two vessels, together with steam-launches, the steamer Blake at Providence was re-sheathed with copper, bilge keels re-secured after an injury in grounding, and fitted with electric lights for the more rapid prosecution of the work for which she is equipped.

A new steam-launch was purchased to replace one condemned as unfit for use in Puget Sound. It is believed that this new boat, which by your orders has been named the "Fuca," will be a valuable acquisition to the party at work on the topography.

The steamers Bache, Gedney, Endeavor, Hassler, and McArthur, and schooners Eagre, Drift, Brisk, Earnest, Research, Silliman, and Quick, and sloop Steadfast have had more or less extensive repairs made upon them.

Hydrographic Division.—The usual routine duties of the office have continued. Of the large number of charts corrected during the year—nearly 400—some of them, owing to a complete change in the system of buoyage inaugurated by the Light-House Board on the coast of Maine, have made this a duty of considerable magnitude to the Assistant to the Hydrographic Inspector. Lieut. C. T. Hutchins, the incumbent at the date of last report, was detached by the Department in July, 1881, and his place taken by Lieut. R. Clover, U. S. N., who brought to the office an extensive experience in handling charts, together with a previous three years' tour as hydrographer in the Coast Survey. His zealous interest in the subject has it is thought furnished the office with data that makes the present editions of our charts as nearly up to date as the constant changes in the buoys under the direction of the Light-House Board will permit.

In this connection I desire to call your attention to the hearty accord with which the different light-house inspectors through the Board have furthered the endeavors of this division to keep the office supplied with the latest information on the subject of aids to navigation.

The plotting and preparation of the hydrographic sheets from the data sent by the field parties have been carried on as usual in the efficient manner already known to you, by Messrs. Engene Willenbucher, W. C. Willenbucher, and F. C. Donn.

The plotting and drafting of original hydrographic sheets are tabulated as follows:

Names.	Vols.	Angles.	Soundings.	Miles.
E. Willenbucher	59	27,185	94,642	3,012
W. C. Willenbucher	69	18,893	125,805	2,560
F. C. Donn	41	8,329	51,290	1,162
Total	169	54,407	271,737	6,734

In addition to this tabulated work, each of the draughtsmen prepared projections, made tracings of original sheets, corrected Aids to Navigation on charts, and performed other miscellaneous work.

Besides the office work, Mr. W. C. Willenbucher was on field duty for one month, and Mr. Donn for two months.

Very respectfully,

C. M. CHESTER,
Commander U. S. N., Hydrographic Inspector.

General R. D. CUTTS,
Assistant in charge of Office and Topography.

Officers of the Navy on duty in the Coast and Geodetic Survey during the fiscal year ending June 30, 1882.

Name and rank.	Date of attachment.	Remarks.
COMMANDERS.		
J. R. Bartlett	Oct. 23, 1878	Still in survey.
C. M. Chester	Oct. 2, 1877	Do.
LIEUTENANT-COMMANDERS.		
W. H. Brownson	Aug. 11, 1881	Still in survey.
H. E. Nichols	Jan. 22, 1879	Do.
E. B. Thomas	Oct. 8, 1879	Do.
LIEUTENANTS.		
S. W. Very	Apr. 13, 1881	Still in survey.
W. T. Swinburne	May 5, 1879	Do.
Uriel Sebree	Mar. 15, 1878	Detached Oct. 22, 1881.
H. B. Mansfield	Feb. 28, 1881	Still in survey.
Richardson Clover	July 26, 1881	Do.
H. G. O. Colby	Oct. 7, 1880	Do.
C. C. Cornwell	Mar. 7, 1881	Detached Feb. 4, 1882.
Perry Garst	Aug. 29, 1879	Still in survey.
T. Dix Bolles	April 5, 1881	Do.
J. A. H. Nickels	Nov. 8, 1880	Detached Jan. 6, 1882.
H. T. Monohan	July 20, 1878	Still in survey.
L. C. Heilner	Dec. 5, 1878	Do.
E. M. Hughes	June 22, 1880	Do.
Hugo Osterhaus	July 31, 1879	Do.
G. W. Mentz	Aug. 19, 1879	Do.
W. B. Elliott	Jan. 25, 1879	Do.
J. C. Fremont, jr	May 21, 1881	Do.
MASTERS.		
J. C. Fremont, jr	May 21, 1881	Still in survey.
F. A. Wilner	Nov., 1880	Do.
Henry Morrell	Dec. 8, 1879	Do.
H. T. Reich	May 1, 1879	Do.
Lucian Flynne	Nov. 7, 1881	Do.
W. H. Nostrand	Dec. 5, 1878	Detached May 11, 1882.
C. McR. Winslow	Aug. 16, 1881	Still in survey.
Daniel Daniels	Apr. 21, 1882	Do.
M. L. Wood	Sept. 19, 1878	Do.
E. L. Reynolds	Aug. 8, 1878	Detached Nov. 2, 1881.
C. J. Badger	Apr. 21, 1880	
C. H. Amsden	Apr. 6, 1878	Detached Sept. 14, 1881.
J. W. Stewart	Aug. 7, 1878	Detached Aug. 22, 1881.
ENSIGNS.		
F. W. Coffin	May 24, 1880	Still in survey.
W. B. Caperton	Nov. 11, 1880	Do.
W. H. Allen	June 27, 1879	Do.
E. M. Katz	Nov. 22, 1881	Do.
H. T. Mayo	May 1, 1879	Do.
W. D. Rose	Oct. 14, 1879	Detached Apr. 4, 1882.
C. F. Pond	May 1, 1879	Still in survey.
C. S. McClain	Apr. 14, 1882	Do.
E. M. Fisher	Feb. 10, 1882	Do.
H. M. Witzel	Feb. 18, 1882	Do.
O. G. Dodge	May 10, 1881	Do.
J. M. Orchard	Feb. 10, 1882	Do.
J. N. Jordan	July 25, 1881	Do.
H. C. Wackenshaw	June 23, 1882	Do.
A. F. Fechteler	Jan. 24, 1882	Do.
W. V. Bronaugh	Aug. 2, 1881	Do.
F. M. Bostwick	Sept. 28, 1881	Do.
W. M. Constant	June 5, 1882	Do.
Wm. Braunersreuther	June 22, 1881	Detached Aug. 2, 1881.
W. G. Hannum	Feb. 24, 1881	Detached Dec. 1, 1881.
PASSED ASSIST. SURGEONS.		
R. C. Persons	Aug. 10, 1879	Detached June 8, 1882.
E. C. Derr	Sept. 7, 1881	Still in survey.
D. O. Lewis	Mar. 16, 1881	Do.
R. H. McCarty	Apr. 8, 1881	Do.
S. W. Battle	Nov. 17, 1881	Do.
H. G. Beyer	May 31, 1881	Do.
W. A. Corwin	Sept. 8, 1880	Detached Sept. 22, 1881.
J. H. Hall	Nov. 21, 1879	Detached Dec. 16, 1881.
H. T. Percy	Sept. 15, 1879	Detached Nov. 16, 1881.
PAYMASTER.		
W. J. Thomson	Dec. 18, 1880	Still in survey.
PASSED ASSIST. ENGINEERS.		
John Pemberton	Sept. 24, 1878	Detached Oct. 15, 1881.
C. A. Greenleaf	Aug. 19, 1880	Still in survey.
Ralph Aston	Dec. 23, 1878	Detached Mar. 30, 1882.
George H. Kearney	Oct. 5, 1881	Still in survey.
J. T. Bingham	Mar. 4, 1882	Do.
R. W. Galt	Nov. 26, 1879	Do.
R. I. Reid	June 9, 1882	Do.
W. H. Nauman	Nov. 25, 1878	Detached Apr. 22, 1882.

REPORT OF THE DRAWING DIVISION.

Drawing Division.—Mr. W. T. Bright has, as heretofore, had charge of this division, the organization of which, together with the force of regular draughtsmen employed, remained the same as in preceding years.

Appendix No. 4 shows a list of the charts and sketches which were completed or were in progress during the year, and also gives a detailed statement of the work executed by each draughtsman for the same period. The number and names of the employés attached to the division, with a synopsis of the work performed by each, are as follows:

Mr. A. Lindenkohl continued the reduction of the additions, &c., which are made annually to the small scale sailing charts, the off-shore series, and the $\frac{1}{80,000}$ scale coast charts. He has also reduced to a uniform scale and combined the field-work necessary for the proper execution of the smooth drawings intended for photolithography. A number of special charts for scientific study were compiled during the year by Mr. Lindenkohl; and at intervals his attention was given to a proper arrangement of the data required to keep the progress sketches (which accompany the Annual Report of the Superintendent) up to date.

Mr. H. Lindenkohl has been engaged in the preparation of the final drawings for those charts which it was decided to issue by the aid of the photolithographic process; various sketches and diagrams, to accompany the appendices of the annual reports, were also engraved by him on stone; and in addition he executed a number of reduced drawings of topographical and hydrographical work for the different scale-charts.

Mr. L. Karcher has, as usual, constructed the greater number of the projections required for the use of the topographical and hydrographical field parties; made projects for new charts; drawn various diagrams, and been engaged on other work of a miscellaneous character.

Mr. P. Erichsen has been engaged principally in preparing drawings of instruments of precision to accompany various papers appertaining to the annual reports. Of these drawings the most important, and the one showing the greatest detail, illustrates the construction of the new Compensation Base Apparatus.

Mr. E. J. Sommer has prepared various drawings of coast and harbor charts; constructed projections for field use; made a number of tracings and projects, and given much time and study to the preparation of drawings for issue by photolithography.

Mr. C. Junken has applied himself to the construction of hydrographic drawings for the use of the Engraving Division; to the preparation of projections for field parties, and has indicated, as occasion demanded, the new longitudes on the engraved copper-plates of early date. He was detailed from office duty in the latter part of June, to make a survey of a tract of land in Wythe County, Virginia, for the use of the United States Fish Commission.

Mr. T. J. O'Sullivan was engaged, principally, in making fine drawings for issue by the photolithographic process, and compiling sketches to illustrate the annual reports. A number of projects, diagrams, and tracings were also constructed during the year by Mr. O'Sullivan.

Mr. A. B. Graham has, during the year, given much attention to the more technical branches of the work of the division, and has applied a vast number of additions and corrections, by hand, to the chart-room editions, prior to their issue to the public. He has reduced and transferred the shore-line to the new hydrographic and topographic projections for field use, and has made various tracings, &c.

Messrs. J. B. Boutelle and E. L. Taney, Aids, were assigned to the division for duty in November, and up to the time of their departure for field service, in the month of January following, were engaged in coloring buoys and other aids to navigation upon the printed charts.

Mr. H. Eichholtz was employed in keeping up to date the latest edition of the printed charts by the insertion of such additional aids to navigation, changes in position, &c., of which information had been received subsequent to the latest date of issue and printing of the charts. In April he was assigned the general care of the chart rooms, owing to the illness of Mr. Thomas McDonnell, who had for many years been in charge of this important branch of the office. Since Mr. McDonnell's demise, which occurred on the 29th of May, and up to the date of this report, Mr. Eichholtz has continued to discharge the duties required in the management of the chart room.

Miss F. Cadel, who was assigned to the division in June, has been engaged in coloring light-houses and buoys upon the printed charts, prior to their issue for public use.

Appendix No. 3 gives a statement of the information furnished by this and other divisions, during the year, in reply to special calls.

ENGRAVING DIVISION,
July 11, 1882.

SIR: I respectfully submit the following report of work executed in the Engraving Division during the fiscal year ending June 30, 1882:

Number of plates completed, charts	28	
Number of plates completed, sketches and illustrations	23	
		51
Number of plates continued, charts		24
Number of plates commenced, charts	4	
Number of plates commenced, sketches and illustrations	21	
		25
Number of plates that received correction, charts	132	
Number of plates that received correction, sketches	12	
		144
Total number of plates worked upon		244
Number of unfinished plates on hand at the close of the year, charts	39	
Sketches and illustrations	19	
		58

Of the 28 completed chart plates, 10 are new charts, 12 new editions, and 6 reissues.

In Appendix No. 5 I give a list showing in detail the plates on which work has been executed. It should be noted relative to the completed plates that those indicated as "first edition" are now published for the first time from engravings on copper. Those indicated as "edition of 1881," or 1882, have heretofore been published in their present form, or when they had been sufficiently advanced to afford useful information, but have now received extensive additions or corrections from recent surveys. Those indicated as "reissued" are old charts that have been thoroughly overhauled and brought up to date.

Many of the "printing plates" that received correction were on h and four or five times. In addition to the engraving we have had the usual amount of cleaning electrotypes, erasures from altos, drawing and arranging titles, general lettering and notes, marking instruments, &c., that invariably accumulates during the year.

The work of correcting plates of published charts has been greatly augmented during the year by the new arrangement between the Hydrographic Inspector and the Light-House Board for the verification of the Aids to Navigation by the inspectors of the light-house districts, and by the change in the first light-house district in the system of buoying the channels; but as we now receive early notice of any change in the Aids to Navigation, it is probable this class of corrections will not involve so much work another year. Information has been received correcting nearly all the principal charts to a recent date, and a large majority of them have been printed from the corrected plates. But in view of the frequency of the notices received, especially relative to the shifting bars of the Southern coasts, I have found it expedient to print as small a number of impressions at a time as will reasonably supply the demand. As all corrections on file are applied to the plates before printing, it supplies the chart room with more perfect copies for distribution and greatly lessens the number of corrections that have heretofore been made by hand.

The force of the division remains as at the beginning of the year, and has been employed as follows:

Messrs. J. Enthoffer, A. Sengteller, and R. F. Bartle on topography.

Messrs. E. A. Maedel, A. Petersen, J. J. Thompson, W. H. Davis, and F. Courtenay on lettering.

Messrs. W. A. Thompson and H. C. Evans on topography and sounding.

Messrs. E. H. Sipe, I. Wasserbach, and A. C. Ruebsam on lettering and miscellaneous corrections.

Messrs. H. M. Knight and F. W. Benner on sanding.

The printing office was added to the charge of the Engraving Division at the beginning of the year.

The work has been conducted very generally as heretofore, except the reduction in the number of impressions pulled from a plate at one time, as before mentioned.

Two of the presses are constantly in use, one in charge of the foreman of the rooms, Mr. F. Moore, and the other of Mr. D. N. Hoover.

The following is a summary of the printing during the year:

Number of impressions for Chart Room	24,843
Number for Assistant in charge	1,026
Number for Drawing Division	27
Number for Division of Topography	362
Number for Engraving Division	1,939
Number for Hydrographic Inspector	522
Number of Atlantic Coast Pilot charts and views	13,390
Total number of impressions	42,109

In addition to the above, 5,610 impressions of Atlantic Coast Pilot charts and views were printed by J. R. Gedney.

The clerical duties of the division have been most acceptably performed by Mr. J. H. Smoot.

I remain, sir, yours, very respectfully,

HERBERT G. OGDEN,

Assistant, U. S. Coast and Geodetic Survey, in charge of Engraving Division.

Gen. R. D. CUTTS,

Assistant, in charge of Office and Topography.

DIVISION OF TOPOGRAPHY, *July* 1, 1882.

DEAR SIR: The Division of Topography was organized July 11, 1881, as an office division; Messrs. A. E. Burton, E. H. Fowler, and R. E. Peary, as topographical draughtsmen, and Mr. E. Molkow, as clerk and miscellaneous draughtsman, being assigned to me at that time.

During the year the inking of the following topographical sheets has been completed or entirely done, some sheets having been received from the Drawing Division partly inked:

Reg. No. 1486. Dyer's Neck and Petit Manan Island.
Reg. No. 1487. Skillings River.
Reg. No. 1489*a*. Long Island, western part, Blue Hill Bay.
Reg. No. 1489*b*. Long Island, eastern part, Blue Hill Bay.
Reg. No. 1490. Bartlett's Island, Blue Hill Bay.
Reg. No. 1491. Head of Frenchman's Bay and part of Franklin Bay.
Reg. No. 1492. Taunton and Hog Bays.
Reg. No. 1493*a*. James River, from Mayo's Bridge to Lower Rocketts.
Reg. No. 1493*b*. James River, from Lower Rocketts to Graveyard Reach.
Reg. No. 1494. Head of Union River Bay.
Reg. No. 1495. Columbia River, from near Kalama to Columbia City.
Reg. No. 1497*a*. Salt Point to Fisherman's Bay.

The following work has been done upon reproducing worn-out sheets:

Reg. No. 455. Plymouth and vicinity, redrawing completed.
Reg. No. 464. Sea-coast of Virginia, Metomkin Inlet, partly redrawn.

The following drawings for photolithographing have been made:

Site for new Naval Observatory.
Hydrography of entrance to Columbia River.
Sketch showing limits of oyster-beds, James River.
Sketch showing limits of oyster-beds, Tangier Sound.

Sketch showing limits of oyster-beds, Pocomoke Sound.
Section A, Sheet 1. District of Columbia.
Section B, Sheet 1. District of Columbia.

There has also been inked the general topographical map of parts of Maryland and Virginia, as far as completed.

A map of the coast of Maine, east of Gouldsborough Bay, has been made, giving details of triangulation for laying out sheets for survey of topography.

Mr. E. Molkow has during the year acted as clerk to the division, prepared topographical statistics for the annual report, partly redrawn a worn-out topographical sheet, done some miscellaneous drawing, and made translations from the French.

Mr. R. E. Peary resigned October 28, 1881.

Mr. J. F. Bird was during December attached to the division under topographical instruction.

During part of the year I have supervised the inking of original topographical sheets by such field topographers as were engaged at the office on such work.

It gives me pleasure to testify to the earnest and steady application to work during the year of those in my charge and to commend them to your favorable consideration.

Respectfully,

E. HERGESHEIMER,
Assistant, in charge of Division of Topography.

R. D. CUTTS,
Assistant, in charge of Office and Topography.

TIDAL DIVISION, *July* 1, 1882.

DEAR SIR: I respectfully submit this report on the work of the Tidal Division, of which I ave been in charge during the year.

Observations.—Self-registering tide-gauges have been used at the following stations: North Haven, Me.; Providence, R. I.; Sandy Hook, N. J.; Sancelito, Cal.; Kadiak, Alaska; and Honolulu, Sandwich Islands.

The observations at Mazatlan, Mexico, were stopped on account of wharf changes being made there, but it is expected that they will be resumed soon under better conditions. A box-gauge and outfit was furnished last February to the Alaska Commercial Company, to be used by them at Copper Island, off the Asiatic coast of Bering Sea, in obtaining a set of tidal observations for comparison with those made at other points by the Coast Survey. Observations are wanting on the American coast of that sea. I renew my recommendations relative to obtaining tidal observations at Bermuda, and simultaneously on the southern coast of the United States, and completing the sets on the coast of the Gulf of Mexico, interrupted in 1861. These will be necessary for as complete an investigation of the Gulf tides as was intended by Professor Bache when they were commenced. As full information has been given, in the tidal notices under the different sections of the survey, of the observations made with self-registering gauges during the year, it will not be necessary to go into details here.

In the following table I give a list of the observations made with self-registering gauges, received during the year, and therefore not mentioned in my previous annual reports:

Section.	Name of station.	Name of observer.	Kind of gauge.	Permanent or temporary.	Time of occupation. From—	Time of occupation. To—	Total days.
I.	North Haven, Me	J. G. Spaulding	Self-registering	Permanent	April 26, 1881	April 24, 1882	363
I.	Providence, R. I	S. M. Gray	do	Temporary			
II.	Sandy Hook, N. J	J. W. Banford	do	Permanent	June 1, 1881	June 1, 1882	365
X.	Sancelito, Cal	E. Gray	do	do	June 1, 1881	June 1, 1882	365
XII.	Kadiak, Alaska	W. J. Fisher	do	do	March 1, 1881	Nov. 1, 1881	245
	Honolulu, S. I	W. D. Alexander	do	Temporary	Dec. 3, 1880	Dec. 28, 1881	390

There are self-registering gauges now in the office, which need some repairs and new driving clocks to fit them for efficient working.

The tidal observations made by the Hydrographic parties of the survey are inspected by me when received at the office, and most of them are reduced in the Tidal Division. Notices of them will be found in the accounts of work done in the different sections of the survey. Such parties generally use a plain staff divided into feet and tenths, or a box gauge with a float-rod divided in like manner. Sometimes the observations of high and low waters are kept up by them day and night, and frequent observations while sounding; but oftener the observations are kept up only while sounding. This of course results in less perfect work, especially where there is large diurnal inequality or single-day tides. It would be a great improvement to have these observations made more continuous.

Office work.—The observers in charge of the self-registering gauges are now generally required to make tables of the high and low waters and hourly ordinates from the curves before sending them to the office, and these tables are not sent by the same mail as the curves. This is a safeguard against losses, tends to make the observers more skillful and careful, and reduces considerably the work in the office. The observations received from the self registering gauges and hydrographic parties are reduced as soon as they can be conveniently, and the results used in making tide tables for charts, in improving the data for predicting, and for other purposes. A great deal remains to be done, but the reductions and discussions already made have been so extensive that the Division is able to furnish a large amount of information relating to tides to officers of the Survey, United States engineers, civil engineers, and others, and the demand for it is constantly increasing. "Tide tables," containing the predictions for the Atlantic and Pacific coasts of the United States for the year 1883, have been computed by the Tidal Division, and have been published.

The computers employed in this division in the course of the year were R. S. Avery, L. P. Shidy, M. Thomas, and C. B. Turnbull in the office, and J. Downes and J. G. Spaulding out of it.

Mr. Avery, being in charge of the division, inspected all tidal observations when received and prepared them for reduction, attended to the correspondence with observers and others relating to tides, planned and supervised the work on tides and tide-gauges, prepared copy and read proofs, and computed when not otherwise engaged. Mr. Shidy reduced many observations received from hydrographic parties, predicted for places having large diurnal inequality, and aided in a considerable amount of miscellaneous work. Miss Thomas worked on the simpler reductions, continued the work on the hourly ordinates for permanent stations, and aided in miscellaneous work and copying. Miss Turnbull returned to the division on the 23d of January, after a year's employment in the other divisions, and since then has been mostly engaged copying and tracing on a variety of work, and when not thus employed tabulated Honolulu tides. Mr. Downes, by a special contract, made the predictions for certain specified places on the Atlantic coast. Mr. Spaulding computed the predictions for Boston, as he has done hitherto, in addition to his services as a tidal observer at North Haven.

Yours, respectfully,

R. S. AVERY,
In charge of Tidal Division.

Gen. R. D. CUTTS,
Assistant, in charge of Office and Topography.

July 1, 1882.

INSTRUMENTS AND REPAIRS.

DEAR SIR: I have the honor herewith to submit my report of work done in the Instrument Division during the last fiscal year:

Beside the usual routine work of keeping the records and superintending the repairing and adjusting of instruments, a great part of my time during and outside of office hours was occupied

with the "tide predicting machine," invented by Professor Ferrel, for which I arranged the details of construction and prepared the working drawings. I have also superintended its construction at Fauth & Co.'s, and the machine is now so far advanced that its working can be tested. The numerous difficulties encountered in the construction of this intricate piece of mechanism have been successfully overcome. During the last year I re-determined the errors of the dividing engine; this was rendered necessary by the fact that the normal temperature of 98° F. had not been kept up during the comparisons of the new five-meter bars in the adjoining room. The machine was further improved by adding an automatic "cleaner" and stop; the old turbine wheel had become very much worn and was replaced by a new one of my own design, which works with less water and only six pounds pressure. In order to have this pressure uniform, a reservoir has been erected from which this turbine is fed. The speed is now very regular, and the beauty of the lines leaves nothing to be desired. The machine would be nearly perfect if a new axis were provided.

Of other special work done in the instrument shop, I mention the construction of the "vertical comparator," by Mr. J. Clark. He also reconstructed the four 45-inch transits by adding large circles, latitude levels, new eyepieces and diaphragms, and changing the illumination. He also experimented in "dark field" illumination for theodolite telescopes, in order to better observe night signals. He assisted me in comparing the base bars, and for this purpose constructed an apparatus which greatly facilitates the work of comparison. The demands for scales in meters and feet necessitated the overhauling of our length dividing engine; Mr. Clark made an efficient machine out of it. Nearly all the magnetic instruments were repaired and adjusted by Mr. Clark.

Mr. E. Eshleman has been kept busy in getting instruments ready for the field. In addition to this he reconstructed the ruling machines in use in the Engraving Division, and made five reversion pendulums, with their supports, for Assistant C. S. Peirce. He replaced a great many brass alidade rulers by nickel-plated steel ones. Mr. P. Vierbuchen mounted ten geodesic night signal lamps; reconstructed—almost entirely new—45-inch transit No. II, and made twelve pairs of beam compasses of different length for use in the Drawing Division and the field. The 20^{m} chains used with plane tables were examined and adjusted by Mr. Vierbuchen.

Louis Fischer assisted me a great part of the time when engaged in reading the engine circle; he made the new turbine wheel and reconstructed the large Hipp chronograph by substituting the "conical pendulum" regulator for the vibrating spring. The new compensation pendulum for the main office clock was made by him. He assisted Mr. Eshleman in the construction of the reversion pendulum.

S. Kearney made the needed brass work for tripods and telemeters. He is now engaged in making a number of heliotropes.

Respectfully submitted,

G. N. SAEGMULLER,
Chief Mechanician.

R. D. CUTTS,
Assistant, in charge of Office and Topography.

APPENDIX No. 7

DESCRIPTION AND CONSTRUCTION OF A NEW COMPENSATION PRIMARY BASE APPARATUS, INCLUDING THE DETERMINATION OF THE LENGTH OF THE CORRESPONDING FIVE-METRE STANDARD BARS.

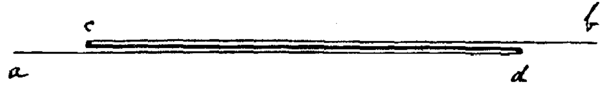
By CHARLES A. SCHOTT, Assistant.

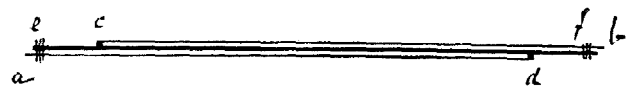
MARCH 10, 1883.

In the Coast and Geodetic Survey Report for 1880, page 40, mention is made by the late Superintendent of a new base apparatus intended for immediate use in California. It was not only desirable to obtain a check or verification of the old secondary base line, measured thirty years ago with plain iron rods, south of San Francisco Bay, but there was an urgent necessity for the supply of a primary base to the great triangulation now spreading along the thirty-ninth parallel from California through Nevada to Utah. In consequence of the complicated and delicate structure of the Bache-Würdemann primary base apparatus hitherto used on the eastern coast, it was thought unsafe to transport it to the western coast for that purpose; besides, its great length rendered the apparatus awkward in handling, and it also required very careful grading of the ground along the line of measure. These considerations determined the Superintendent to call for a design of an apparatus which should combine the accuracy of the old apparatus with facility of transportation, least liability to injury or derangement, ease and economy of measure, rapidity of measure, and minimum preparation of the ground. Of course cheapness of construction was also a leading consideration.

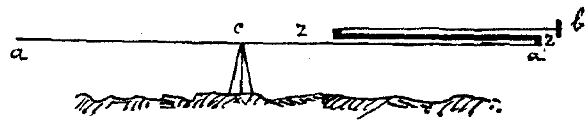
Under date of January 28, 1880, I was charged by the Superintendent with elaborating a design and submitting a report explanatory of the principles for constructing such an apparatus. This report was submitted February 9, when I was further directed to work out the plan in detail and, with the assistance of Mr. W. Suess, mechanician, prepare working drawings. This plan was submitted March 1, and was accompanied by two large sheets of drawings. Before adopting the design it was sent to Assistant G. Davidson for his criticism, and his suggestions, contained in two reports and bearing on matters of detail, were carefully considered and in part adopted. Respecting the important questions of the best length to be given to the measuring bars, and whether they should be compensating for temperature or plain bars, I decided for a length of five metres and for compensation. Supposing the bars well standarded, the greater their length the greater the accuracy of the line measured, and the greater the rapidity of measure; the maximum length, therefore, had to be taken. The four-metre bars were known to be too short, but the six-metre bars of the Bache-Würdemann primary apparatus were judged to be too long, especially when a less cumbersome apparatus had to be secured against deformation; five metres (or 16.4 feet) seemed to be practically the best length. Considering the large range of the diurnal variation of temperature in the region where the apparatus was to be used, and the greater accuracy which a compensation-bar would insure, that principle was adopted; yet it was deemed sufficient to conform to it approximately.

Principal features of the new design.—Although the apparatus involves no new mechanical principle, it is nevertheless unlike any other yet constructed. It may be briefly described in its general outlines as follows: The measuring bar is composed of two metals so proportioned as to be compensating for changes of temperature, and rigidly connected without any points, levers, or movable parts; thus in fact, forming a rigid system five metres in length. Referring to the annexed diagram, the middle (or heavy) bar is of zinc, and riveted to it at *c* and *d* are two steel bars terminating at *a* and *b*, which points remain at an invariable distance from each other and constitute the length of the measuring bar. The expansion or contraction of the zinc bar is exactly counteracted by the expansion or contraction of the two steel bars, provided the proper relative length be given to the bars. The coefficient of expansion of zinc being nearly 2¾ times that of steel, the zinc bar is the shorter one. To control the length of the apparatus with respect to any outstanding small differential expansion, the zinc bar is allowed to project beyond the points *c* and *d* toward *a* and *b*, where Borda scales at *e* and *f* are applied, as indicated in the accompanying diagram by three cross-lines. The readings of the scales mutually check each other, and the part *c* to *d* of the zinc bar enters in both. There are also mercurial thermometers inserted for additional security. The length of the measuring bar is ascertained by frequent direct comparisons with a standard five-metre bar in the comparing room, as well as in the field. Two such standards were constructed, one to remain at the office at Washington, the other to accompany the apparatus into the field; they consist of a steel bar five metres in length, with zinc bars of about half that length riveted to it at *m* and *n* of the diagram, one on each side, so as to form *two* Borda scales, as indicated by the three cross-lines. This disposition of the bars was adopted to secure correctness of indication of length of steel bar under any unequal exposure to heat or cold with respect to the two sides of the bar. Mercurial thermometers were also provided.





The "Mudge" contact slide, so effective in our secondary apparatus, was also adopted for the present apparatus in the place of the complex spirit-level contact of the six-metre bars. That feature of the B.-W. apparatus which secures during measure, by mechanical compensation, an invariable distance between the rear trestle support and the rear end of the bar, is retained in the new apparatus in a somewhat different way, as shown by diagram, where the distance *c b* is invariable by the action of the zinc bar *z z* in a direction contrary to that of the two iron bars, viz, that terminating at *b*, and but little longer than the zinc bar, and the other, that part of the T-shaped iron rail *a a′* which is contained between *c* and *a′*. This rail actually forms the support of the measuring bar, and carries the rollers upon which the latter rests. It is important to notice that the end *b* forms the *abutting* surface for the action of the screw head, by the turning of which the rigid-bar system can be moved on its rollers longitudinally, and by means of which *contact* is made. The diagram shows this compensation in a vertical plane merely for greater distinctness; actually, the arrangement is in a horizontal plane, and there are two zinc and two steel bars, as will be more fully explained hereafter.



The trestles are of wood, modeled after those of the secondary apparatus, but lower and very much heavier and stronger, with the following additions or changes: A prism on the rear trestle which fits into any one of a series of notches on the under side of the measuring bar (at *c* of the preceding diagram); this prism can turn about a vertical axis passing through the middle of its ength and thus admits of a slight azimuth motion; attached to the top of each trestle is a horizontal screw (added in California), by means of which the bar when resting on the trestles can be aligned rapidly. During measure each leg of the trestles rests on an iron foot-plate, triangular in shape, with a prong at each angle to hold it firmly on the ground. The aligning telescope is the same as used with the secondary apparatus, but it is mounted and adjusted differently, the place assigned to it being at the forward end of each bar. A sector for measuring the inclination of the bar is provided as usual. It is intended that the apparatus shall be protected from the rays of the sun during measure, and it is supposed that the temperature will then rarely much exceed the limits of 0° and 40° C. For transferring the end of a bar to the ground, a theodolite (so-called sector) is provided; it is mounted a few metres off the line of the base and approximately at right angles thereto and opposite the end to be sighted; a finely divided ivory scale is placed level and over the line mark on the ground, and read off by means of the telescope which is adjusted to move in a vertical plane. In height the telescope is midway between the ground and the base bar, thus requiring no attention in the focal length.

Respecting the employment of zinc in the construction of the apparatus I felt no hesitation, considering that it was successfully employed by Bessel in his apparatus as his temperature indicator, yet to some extent I conceive it to be an experiment, for want of complete knowledge of the behavior of this metal under variations of temperature; daily comparisons with the standard bar during the measurement of a base were therefore deemed essential and a portable comparator or a fixed one of easy access had to be provided.

In consequence of the condition of the Survey at the time not admitting of any additional expenditures, nothing further could be done during the fall of 1880 than to select a suitable comparing room in the basement of the office and to erect therein several brick piers to serve for the comparisons needed in the construction of the five-metre standards. It was, however, difficult to control the temperature of this room, and the space was very much confined and barely sufficient, yet nothing better could be had. Several weeks were lost during the winter in the attempt to obtain suitable steel and zinc bars, and it was not until the middle of February, 1881, that they were procured; from that time the work proceeded rapidly, and the apparatus was completed June 25, 1881, and inspected on that day by the late Superintendent. It was then ordered to be sent immediately to California. It is to be regretted that there was no time to test the performance of the apparatus here, and in consequence, some minor imperfections were noticed during the field work. The construction of the apparatus was entrusted to me at a period when the discharge of my ordinary official duties required almost the whole of my time, and I found myself so seriously embarrassed in consequence, that in the spring I had to request the aid of Sub-Assistant Blair to supervise the mechanical execution of the apparatus, the work not being done at the office, but scattered among various mechanics. I have also to acknowledge the effective help of Mr. W. Suess, for general assistance and especially for work required in the comparing room, such as the construction of the movable platform, the adjustment of the bars and comparators, and the observations themselves. All computations in connection with the comparisons of length and determination of coefficients of expansion were made by myself and checked by Mr. J. G. Porter of the Computing Division, who also made the computations of the additional work of 1883, which was checked by another computer.

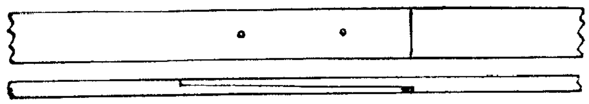
Description of some details of the base apparatus.—In order to avoid the necessity of a tedious description two plates of illustrations have been prepared, see Plates Nos. 26 and 27. These plates contain detail drawings of the apparatus as a whole and of all such parts as appear to require further elucidation; the figures are drawn to scale, hence any desired dimensions may readily be measured off, besides a title or description sufficient to make further remarks unnecessary accompanies each figure, and it is believed that these, taken in connection with the above exposition of the principles of the construction, will render it practicable to obtain a complete knowledge of the apparatus.

The standard bars.—The office and field standards are of precisely the same construction. These steel bars are of rectangular section 5mm thick by 21.5mm high; the attached zinc bars are 6mm by 25mm and 249cm in length. The united bars rest on sixteen equidistant rollers placed on the top of an iron T-rail. At each end of the steel bar and projecting beyond the wooden case are steel plugs 2.5mm in diameter and 1mm long, the end surfaces of which define the length of the standard. Sunk in the box and read through glass windows are two mercurial thermometers. The two Borda scales on each standard are 20mm in length, divided into quarter millimetres with vernier; their least reading is 0.01mm, corresponding to an expansion of abou °C.

The base bars.—The two bars are of the same construction. The cross-section of the steel is 5.5mm thick and 23mm high, and that of the zinc bars 6.2mm by 25mm. Let s = length of each of the two steel bars and z that of the zinc bar between them, and considering that there is about 0.16 of brass forming the contact pieces at each end, we have the expression

$$2s + .16 - z = 5$$
$$2\alpha s + .16\gamma - \beta z = 0$$

where α, β, γ are the coefficients of expansion of the respective metals; putting $\alpha = 6.56$, $\beta = 17.82$ and $\gamma = 10.0$, we find $s = 3.90$m and $z = 2.96$m nearly, which ar· the respective lengths of the pieces forming the rigid measuring bar. In consequence of the impracticability of obtaining a bar of zinc of this length, two pieces had to be joined; they are scarfed, spliced and riveted as shown by the diagram.

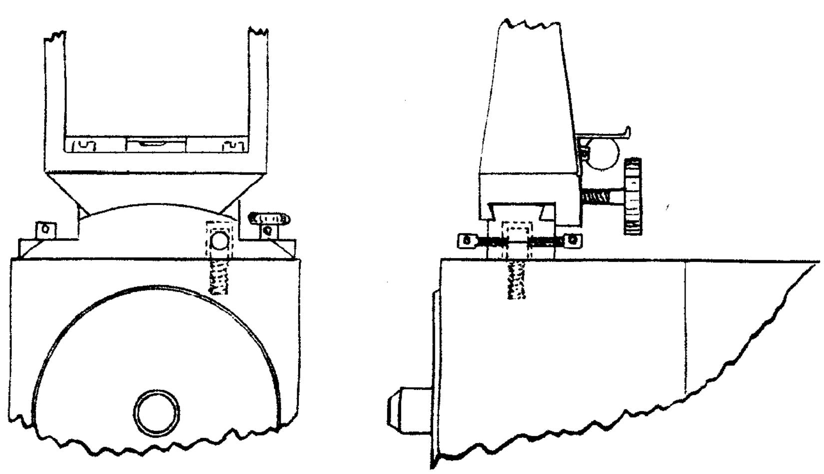


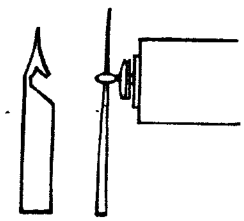
The effective length for differential expansion is, for base bar No. 1, 3.802m, and for base bar No. 2, 3.808m.

In order that the compound measuring bar should at all times retain its length whether the temperature be rising or falling, it was desirable that the cross-sections of the steel and zinc bars should be inversely proportional to the specific heat of these metals; also that the thickness of the bar should take into account the difference in the conductivity of heat, and that the bars should have equal surface exposure so that radiation (or absorption) might be the same. These conditions can only be approximately satisfied; besides the dimensions desired differ from the actual ones in consequence of the inability to have the manufacturer conform to a given exact form. These remarks apply to the standard bars as well. The length of the measuring bar is defined by steel plugs, that at the rear end being ground into a horizontal knife-edge, while that at the forward end is flat and perpendicular to the length of the bar.

No attempt was made to compensate the bar for increased expansion at high temperatures.

The Mudge contact slide has added to it a collar or ring, by the turning of which contact can be made and the sliding piece kept in position; this contrivance was necessary in order that the sliding piece may not press against the comparator during comparisons for length, the Bessel-Repsold as well as the Fauth comparator being lever and spirit-level comparators. In the place of the usual single line there are three equidistant lines for coincidence, one set ruled slightly closer as suggested by Assistant Davidson; contact is made with the aid of a magnifying glass. In consequence of dust penetrating into the slide it was necessary to cut it through, so that it could be removed for cleaning without disturbing the small index piece. The strength of the interior contact spring is a pressure of but a small fraction of an ounce. The aligning telescope is copied from the secondary apparatus, for which see Appendix No. 17, Coast and Geodetic Survey Report for 1880, but the mounting and means of adjustment are different; the whole slides on an arc concentric with the axis of the bar, and is set vertical by means of a small spirit level; in this position it can be clamped. It was originally adjusted by hand in *azimuth* and kept in alignment by a clamp, but Sub-Assistant Pratt suggested the addition of an abutting stud with two adjusting screws working against it, as shown on the accompanying diagram.





He also independently suggested the use of a suspended pin at the rear end of the measuring bar, as had been thought of by me for adjusting the telescope in direction, but the latter operation was easily effected by means of sighting on a plumb-line suspended over the middle of the knife-edge. The hook as suggested is shown by accompanying cut.

The compensation arrangement at the rear end of the bars, in consequence of which the abutting surface of the contact screw, which moves the whole measuring bar, remains at an invariable distance from the position of the rear trestle at the time, is effected by zinc bars 0.50m in length.

The whole apparatus rests on two trestles $\frac{5}{\sqrt{3}}=2.887$ metres apart, and equidistant from the ends. The number of grooves under the rear end of the bar was about two to the centimetre, cut afterwards so as to have four per centimetre; and there might, with advantage, be five grooves per centimetre. In general plan the trestles do not differ from those used with the secondary apparatus, but they are very much stouter and heavier and have the following additions: A horizontal knife-edge or prism, which can turn about a vertical axis so as to accommodate any one of the above grooves in case the trestle should be somewhat turned with respect to the direction of the line. By letting the bar down on any selected groove the distance between the front bar and the rear bar could be so regulated that but a small motion in the direction of its length is required to effect the contact. The roller on the front trestle is of metal instead of wood, in consequence of the larger weight it has to bear. To facilitate adjustment of the bar in direction, the pulling or pushing of it into line being found too clumsy and time-consuming, Assistant Gilbert fitted an endless screw to each trestle, the threads working against a pin or projection underneath the bar; by these means, which were applied during the measure of the Yolo base, the alignment of the bar could be made with great ease and precision. In height the bar is regulated by the usual wedges of the secondary apparatus; the legs of the trestles are shorter than usual, and the split parts are connected in the middle by a cross-bar.

The remaining pages contain an account in detail of the method adopted for the determination of the length of the two five-metre standards and of the results reached; also a direct comparison of these standards with a four and a six-metre standard, as heretofore used on the survey.

DETERMINATION OF THE LENGTH OF TWO FIVE-METRE STANDARD BARS IN CONNECTION WITH THE NEW FIVE-METRE COMPENSATION BASE APPARATUS OF 1881.

Value of one turn of the Bessel-Repsold Comparators I and II, used for standarding the two five-metre standard bars, and investigation of inequalities of screws.

Their value is derived from observations involving the length of a brass centimetre, a brass decimetre, and the brass Saxton machine-metre, viz:

A.—*Length of the Saxton dividing and comparing machine-metre, also known as the Stop-metre, in terms of the iron Committee-metre (of 1799).*

The new discussion of the several series of observations led to the following table of results, where C_m and S_m stand for Committee-metre and Stop-metre, respectively:

Date of observations.	Observer.	$C_m—S_m$	Temp.	Obs.—Comp.
			° F.	
March, 1879	J. J. Clark	184.1μ	83.8	−0.8μ
July, 1874	M. Meigs	207.1	77.2	−0.6
April, 1872, and September, October, 1878	A. H. Scott and J. J. Clark	238.1	68.9	+1.8
January, 1879	J. J. Clark	367.1	30.8	−0.5

Combining these results by the method of least squares, they give:

$C_m - S_m = 363^{\mu}.423 - 3^{\mu}.446\,(t - 32^\circ \text{ F.})$ in microns or millionth parts of a metre, with a probable error of $\pm 0^{\mu}.4$

The length of the Committee-metre equals $1^m + 6^{\mu}.550\,(t-32^\circ \text{ F.})$ hence

$$\pm 1$$

$$S_m = 999\ 636.58 + 9.996\,(t - 32^\circ \text{ F.}) \text{ expressed in microns}$$
$$S_m = 1^m \text{ at } 68^\circ.36 \text{ F., or at } 20^\circ.20 \text{ C.}$$
$$\pm .10 \qquad \pm .05$$

[The coefficient of expansion of the C_m is derived from the observations of December, 1880, and January and February 1881, for which see further on.]

B.—*Length of the brass standard decimetre, also designated D_{1878}, in terms of the S_m and the C_m.*

The new discussion of the comparisons made by J. J. Clark in May and June, 1878, gave the result $10\ D_{1878} = S_m + 39^d.3$ at $68^\circ.73$ F. One division of the eye-piece micrometer of the Saxton machine equals $2^{\mu}.525$, viz: From observations of October 5 and October 8, 1878, January 8, 1879, by J. J. Clark, of February 14, 1880, by E. D. Preston, and of October 14, 1880, by H. W. Blair, the observers using the 10mm. spaces of the brass scale C_{1878} (which see below).

$$C_{1878} \text{ at } 61^\circ.6 \text{ F.} = 3959^d.2 \text{ hence } 1^d = 2.525\mu$$

and

$$D_{1878} \text{ at } 68^\circ.73 \text{ F.} = 0.100\ 010\ 32^m$$

This decimetre and the centimetre of 1878 are of the same kind of brass as that of the S_m hence

$$D_{1878} = 0^m.1 \text{ at } 58^\circ.41 \text{ F.,}$$

and at any temperature t

$$D_{1878} = 0^m.1 + 1^{\mu}.000\,(t - 58^\circ.41 \text{ F.})$$
$$= 0\ .1 + 1\ .799\,(t - 14\ .67 \text{ C.})$$

C.—*Length of the brass standard centimetre, also designated C_{1878}.*

The new discussion of the comparisons made by J. J. Clark in October, 1878, gave the result:

$$C_{1878} = \tfrac{1}{10} D_{1878} - 2^{\mu}.85, \text{ both pieces at } 64^\circ.9 \text{ F.}$$

hence

$$C_{1878} \text{ at } 64^\circ.9 \text{ F.} = 0^m.01 - 2^{\mu}.20$$

and

$$C_{1878} = 0^m.01 \text{ at } 86^\circ.90 \text{ F.}$$

At any temperature t

$$C_{1878} = 0^m.01 + 0^{\mu}.100\,(t - 86^\circ.9 \text{ F.})$$
$$C_{1878} = 0\ .01 + 0\ .180\,(t - 30\ .5 \text{ C.})$$

D.—*Value of one turn of the Bessel-Repsold Comparators I and II.*

Observations made by H. W. Blair on November 18, 19, 26, 1880, depend on the length of D_{1878}, those of November 22, 1880, on the length of C_{1878}.

November 18, 26..Comp. I	36.2231 turns = D_{1878} at 56°.9 F. hence 1 turn of screw = 276$^{\mu}$.06
November 19.....Comp. II	36.1890 turns = D_{1878} at 58 .4 F. hence 1 turn of screw = 276 .33
November 22.....Comp. I	36.2114 turns = C_{1878} at 29 .1 F. and 36.2148 t = C_{1878} at 74°.3 F.
Comp. II	36.1800 turns = C_{1878} at 28 .7 F. and 36.1857 t = C_{1878} at 74 .7 F.

Hence

1 turn of Comp. I at	29°.1 F	275$^{\mu}$.99	and 1 turn of Comp. II at 28°.7 F	276$^{\mu}$.27
	56 .9 F	276 .06	58 .4 F	276 .33
	74 .3 F	276 .09	74 .7 F	276 .35
1 turn at	57 .0 F	276 .06	1 turn at 58. 0 F	276 .33
		±.01		±.01

and finally

$$1 \text{ turn of Comp. I} = 276^{\mu}.06 + 0^{\mu}.002\,(t - 57^\circ \text{ F.})$$
$$\pm 0\ .01$$
$$1 \text{ turn of Comp. II} = 276\ .33 + 0\ .002\,(t - 58^\circ \text{ F.})$$
$$\pm 0\ .01$$

or

$$1 \text{ turn of Comp. I} = 276\ .06 + 0\ .0036\,(t - 14^\circ \text{ C.})$$
$$\pm 0\ .01$$
$$1 \text{ turn of Comp. II} = 276\ .33 + 0\ .0036\,(t - 14^\circ \text{ C.}) \text{ microns}$$
$$\pm 0\ .01$$

E.—*Inequalities of the screws of Comparators I and II.*

The screws of the comparators were tested and the corrections determined for periodic inequality in the fractions of a turn and for difference in values of whole turns, according to the method devised by Bessel, and given in his "Astronomische Untersuchungen, Vol. I, Königsberg, 1841." The observations were made by H. W. Blair.

For the investigation of the periodic inequality measures were taken, November 12 and November 15, 1880, for quarter and half turns, for which I find

For Micrometer Screw I:

$$\varphi u = u - {}^{t}.00014 \cos u + {}^{t}.00010 \sin u - {}^{t}.00005 \cos 2u - {}^{t}.00006 \sin 2u$$

For Micrometer Screw II:

$$\varphi u = u + .00031 \cos u - .00018 \sin u - .00030 \cos 2u - .00040 \sin 2u$$

These expressions indicate that practically there is no inequality in the subdivisions of a turn. Here u = reading of screw-head and φu its correction.

Observations were made November 16 and 17, 1880, for inequality of whole turns and ranging over the whole scale from 0 to 80 turns; for each comparator there were 26 equations with 11 unknown quantities; and if f indicates a correction to a reading of turns, I find

For Micrometer Screw I:
$$\begin{cases} f\,10 = -{}^{t}.0194 \\ f\,20 = -.0384 \\ f\,30 = -.0515 \\ f\,40 = -.0527 \end{cases} \qquad \begin{cases} f\,50 = -{}^{t}.0463 \\ f\,60 = -.0323 \\ f\,70 = -.0139 \\ f\,0 \text{ and } f\,80 \text{ being zero} \end{cases}$$

For Micrometer Screw II:
$$\begin{cases} f\,10 = -.0335 \\ f\,20 = -.0623 \\ f\,30 = -.0872 \\ f\,40 = -.0967 \end{cases} \qquad \begin{cases} f\,50 = -{}^{t}.0795 \\ f\,60 = -.0498 \\ f\,70 = -.0225 \\ f\,0 \text{ and } f\,80 \text{ being zero} \end{cases}$$

Applied to the observed intervals of 10, 20, 30, and 40 turns, they exhibit the remaining discrepancies as given below.

Table of remaining differences (in fractions of a turn).

Interval of	Comparator No. I.				Comparator No. II.			
	10 turns.	20 turns.	30 turns.	40 turns.	10 turns.	20 turns.	30 turns.	40 turns.
0t	+.0013	−.0118	+.0045	+.0060	−.0043	+.0003	−.0015	+.0055
10	+.0039	−.0046	+.0023	+.0002	−.0015	−.0013	−.0030	+.0018
20	+.0005	−.0034	−.0021	−.0033	+.0006	−.0041	+.0050	−.0027
30	−.0039	+.0061	−.0027	+.0007	+.0022	−.0057	+.0034	−.0024
40	−.0020	+.0077	−.0013	−.0034	.0000	+.0041	−.0014	−.0024
50	−.0011	+.0039	−.0008	....	+.0005	+.0030	−.0027	....
60	−.0010	+.0015	....	....	+.0014	+.0037	....	....
70	+.0025	....	....	....	+.0007	....	....	....

The corrections f for intermediate turns were obtained by interpolation; for this purpose I used Hansen's interpolation formula,[1] arranged according to powers of the fractional part of the argument. If F be the function, $F^{(n)}$ an interpolated value, and n the interval, here 10 turns, then

$$
\begin{aligned}
F^{(n)} = F &+ n\left(a - \frac{1}{6}c + \frac{1}{30}e - \quad . \quad . \quad . \quad . \quad . \right) \\
&+ n^2\left(\frac{b}{2} - \frac{d}{24} + \frac{f}{180} - \quad . \quad . \quad . \quad . \right) \\
&+ n^3\left(\frac{c}{6} - \frac{e}{24} + \quad . \quad . \quad . \quad . \quad . \right) \\
&+ n^4\left(\frac{d}{24} - \frac{f}{144} + \quad . \quad . \quad . \right) \\
&+ n^5\left(\frac{e}{120} - \quad . \quad . \quad . \quad . \right) \\
&+ n^6\left(\frac{f}{720} - \quad . \quad . \quad . \right) \\
&+ \text{etc.}
\end{aligned}
$$

A table of corrections was thus computed for every turn and the corrections were also laid down graphically.

The following table of corrections suffices for most purposes. It is part of a more extended table which gives the corrections for every tenth division of a turn. It was computed from the expressions

For Micrometer No. I:

$$F^{(n)} = -^{t}.0527 + .00308\,n + .00350\,n^2 - .00051\,n^3 + .00033\,n^4 + .00003\,n^5 - .00003\,n^6$$

For Micrometer No. II:

$$F^{(n)} = -^{t}.0967 + .00408\,n + .01469\,n^2 - .00023\,n^3 - .00141\,n^4 - .00000\,n^5 + .00007\,n^6$$

where

$$n = \frac{1}{10}(t - 40)$$

Table of corrections to turns of Micrometers I and II.

Turns.	Correction to		Turns.	Correction to		Turns.	Correction to		Turns.	Correction to	
	I.	II.		I.	II.		I.	II.		I.	II.
10	$-^{t}.020$	$-^{t}.033$	25	$-^{t}.047$	$-^{t}.075$	40	$-^{t}.053$	$-^{t}.097$	55	$-^{t}.040$	$-^{t}.065$
11	.021	.037	26	.048	.078	41	.052	.096	56	.039	.062
12	.022	.041	27	.049	.081	42	.052	.095	57	.037	.059
13	.024	.044	28	.050	.083	43	.052	.094	58	.036	.056
14	.026	.047	29	.051	.085	44	.051	.093	59	.034	.053
15	−.028	−.049	30	−.052	−.087	45	−.050	−.091	60	−.032	−.050
16	.030	.052	31	.052	.089	46	.050	.089	61	.031	.047
17	.032	.055	32	.053	.091	47	.049	.087	62	.029	.044
18	.035	.057	33	.053	.093	48	.048	.085	63	.027	.042
19	.037	.060	34	.053	.094	49	.047	.082	64	.025	.039
20	−.038	−.062	35	−.053	−.095	50	−.046	−.079	65	−.023	−.036
21	.040	.065	36	.053	.096	51	.045	.077	66	.021	.034
22	.042	.067	37	.053	.097	52	.044	.074	67	.019	.031
23	.044	.070	38	.053	.097	53	.043	.071	68	.017	.028
24	.045	.073	39	.053	.097	54	.042	.068	69	.016	.025
									70	−.014	−.022

N. B.—The measures taken of D_{1878} and C_{1878} for the determination of the values of one turn of the micrometer screws were corrected by means of the above table.

[1] Chauvenet's Practical Astronomy, Vol. I, p. 89, Philadelphia, 1863.

Table of values of one turn of Micrometers I and II for various temperatures.

C.	F.	Micrometer I.	Micrometer II.
°	°	μ	μ
0	32	276.01	276.28
10	50	.05	.32
20	68	.08	.35
30	86	.12	.39
40	104	.15	.42

VALUE OF ONE TURN OF THE FIELD COMPARATORS MADE BY FAUTH & CO., MAY, 1881 KNOWN AS SCREW-LEVEL COMPARATORS III AND IV; AND INVESTIGATION OF IRREGULARITIES OF SCREWS.

The value of a turn of these screws depends on the length of the standard brass centimetre C_{1878}.

A.—*Value of one turn of the Fauth & Co. Comparators III and IV.*

Observations made by H. W. Blair May 17, 18, 24, 1881, at a mean temperature of 72°.1 F., on June 3, 4, 1881, at a mean temperature of 68°.2 F., and on June 20, 21, 1881, at various temperatures, ranging from 85° F. to 44° F., give the following results:

Comparator III: 39.2812 turns$=C_{1878}$ at 68°.5 F. hence one turn of Screw III$=254.528^{\mu}$
Comparator IV: 39.2794 turns$=C_{1878}$ at 66 .7 F. hence one turn of Screw IV$=254.535^{\mu}$

One turn of Comparator III$=254^{\mu}.53+0^{\mu}.001\,(t-68°\text{ F.})$
$\pm 0\ .01$

One turn of Comparator IV$=254\ .53+0\ .001\,(t-68°\text{ F.})$
$\pm 0\ .01$

Or one turn of Comparators III and IV$=254^{\mu}.53+0^{\mu}.002\,(t-20°\text{ C.})$
$\pm 0\ .01$

B.—*Inequalities of the screws of Comparators III and IV.*

For the investigation of any periodic inequality in the fractions of a turn of the screws, measures were taken by H. W. Blair, May 16 and June 2, 1881, for quarter and half turns. They give

For Micrometer Screw III:

$$\varphi u = u - {}^{t}.00084 \cos u - {}^{t}.00025 \sin u - {}^{t}.00044 \cos 2u + {}^{t}.00045 \sin 2u.$$

For Micrometer Screw IV:

$$\varphi u = u - .00048 \cos u + .00019 \sin u + .00022 \cos 2u - .00015 \sin 2u.$$

These corrections are too small to need consideration in our work.

For inequality in whole turns, ranging over the whole scale from 0 to 80 turns, observations were made by H. W. Blair, May 17 and June 2, 1881. From these the following corrections were derived:

For Micrometer Screw III:
$f\ 10 = +{}^{t}.0101$
$f\ 20 = +\ .0109$
$f\ 30 = -\ .0028$
$f\ 40 = -\ .0099$
$f\ 50 = -{}^{t}.0118$
$f\ 60 = -\ .0098$
$f\ 70 = -\ .0052$
f 0 and f 80 being zero

For Micrometer Screw IV:
$-.00$
$f\ 20 = -\ .0001$
$f\ 30 = -\ .0078$
$f\ 40 = -\ .0102$
$f\ 50 = -\ .0078$
$f\ 60 = -\ .0043$
$f\ 70 = -\ .0023$
f 0 and f 80 being zero

When applied to the observed intervals of 10, 20, 30, 40 turns, the measures exhibit the remaining differences (in parts of turns) as before.

Interval of	Comparator No. III.				Comparator No. IV.			
	10 turns.	20 turns.	30 turns.	40 turns.	10 turns.	20 turns.	30 turns.	40 turns.
0^t	−.0067	+.0006	+.0001	+.0056	−.0002	+.0025	−.0001	−.0020
10	+.0030	−.0012	−.0051	−.0029	−.0011	−.0011	+.0036	−.0015
20	+.0030	−.0021	+.0042	−.0012	+.0087	−.0060	−.0005	−.0010
30	+.0066	−.0003	−.0036	−.0009	+.0035	+.0006	−.0003	+.0037
40	+.0023	+.0043	−.0014	−.0006	−.0002	+.0025	−.0039	+.0009
50	−.0048	+.0023	+.0057	....	−.0026	−.0004	+.0015	....
60	−.0017	−.0035	....	....	−.0036	+.0019	....	....
70	−.0016	....	....	....	−.0043	....	....	....

For the interpolation of tabular values for each turn, we have
For No. III:

$$F^{(n)} = -^t.0099 - .00390\, n + .00247\, n^2 - .00069\, n^3 + .00016\, n^4 + .00009\, n^5 - .000032\, n^6$$

For No. IV:

$$F^{(n)} = -\ .0102 + .00060\, n + .00249\, n^2 - .00066\, n^3 - .00009\, n^4 + .00006\, n^5 - .000009\, n^6$$

where

$$n = \frac{1}{10}(t - 40)$$

Table of corrections to turns of Micrometers III and IV.

Turns.	Correction to III.	Correction to IV.	Turns.	Correction to III.	Correction to IV.	Turns.	Correction to III.	Correction to IV.	Turns.	Correction to III.	Correction to IV.
10	$+^t.010$	$-^t.001$	25	$+^t.004$	$-^t.004$	40	$-^t.010$	$-^t.010$	55	$-^t.011$	$-^t.006$
11	.012	.000	26	.002	.005	41	.010	.010	56	.011	.006
12	.014	+.001	27	+.001	.006	42	.011	.010	57	.011	.005
13	.015	.002	28	.000	.007	43	.011	.010	58	.010	.005
14	.015	.002	29	−.002	.007	44	.011	.010	59	.010	.005
15	+.015	+.002	30	−.003	−.008	45	−.011	−.009	60	−.010	−.004
16	.015	.002	31	.004	.008	46	.012	.009	61	.009	.004
17	.014	.002	32	.005	.009	47	.012	.009	62	.009	.004
18	.013	.001	33	.006	.009	48	.012	.008	63	.008	.003
19	.012	+.001	34	.007	.010	49	.012	.008	64	.008	.003
20	+.011	.000	35	−.007	−.010	50	−.012	−.008	65	−.007	−.003
21	.009	−.001	36	.008	.010	51	.012	.007	66	.007	.003
22	.008	.002	37	.009	.010	52	.012	.007	67	.006	.003
23	.006	.003	38	.009	.010	53	.012	.007	68	.006	.002
24	.005	.004	39	.010	.010	54	.012	.006	69	.005	.002
									70	−.005	−.002

N. B.—The measures taken of C_{1876} for determining the value of one turn of micrometers were corrected by means of the above table.

Table of values of one turn of Micrometers III and IV for various temperatures.

C.	F.	Micrometer III.	Micrometer IV.
°	°	μ	μ
0	32	254.49	254.50
10	50	.51	.52
20	68	.53	.53
30	86	.55	.55
40	104	.57	.57

DETERMINATION OF THE LENGTH OF THE NEW FIVE-METRE STANDARD BARS KNOWN AS FIVE-METRE OFFICE STANDARD AND FIVE-METRE FIELD STANDARD, OR SIMPLY AS FIVE-METRE STANDARDS No. 1 AND No. 2.

They are of steel, end measures with steel plugs, and have attached two zinc bars with Borda scales in the middle, as described in the account of the construction of the new five-metre base apparatus.

They depend for their length on the Committee metre as unit, and indirectly on the length of five steel metres made for the purpose, and known as subsidiary metres A, B, C, D, E.

a.—Description and determination of the length of the five subsidiary steel metres A, B, C, D, E.

The steel bars were made about twelve years ago, and were taken from a number of similar bars which served for the construction of the steel standard State-metres. They are rectangular in section, 1cm in width and 3cm in height, nearly that of the Committee metre which is 9mm by 28mm; originally they had at one end a rectangular perforation 4mm. by 9mm. This was filled up with lead. At the end surfaces there are projecting cylinders 1cm long and 1cm in diameter, and slightly projecting beyond the ends of these cylinders, and concentric therewith, are the defining platinum-iridium surfaces, 2mm in diameter and projecting about 0.5mm beyond the cylinder. The alloy proved rather soft and would wear under rough or constant use. The platinum-iridium cylinders were inserted by J. J. Clark, who ground and polished them at right angles to the axes of the bars, and standarded them as near as practicable to the length of one metre; when not in use the ends are protected by brass caps and the bars are preserved in wooden boxes.

For the determination of their length they were placed side by side in a trough filled with glycerine, and compared between the middle brick piers in the comparing-room by means of the Bessel-Repsold screw-level comparators, and at the natural temperature of the room. The fluid was poured in the trough the evening before observations commenced, and after the close of each day's work the metres were newly arranged in relative position. There are two thermometers in the tank, suspended horizontally and on a level with the axes of the metres and on each side of the box. To read them without taking off the lid there are two glass windows vertically over the scales; the thermometers are fastened to iron bars of the same section as the metres; these bars can be raised by means of wires, in order to bring the stems of the thermometers to or above the surface of the glycerine for the purpose of reading the scales. The readings are taken by the light of a bull's eye lantern; a small plane mirror fastened on the outside over the lens and inclined to the horizon about 45° throws the light vertically downward. Before reading the thermometers the glycerine is agitated and made to circulate freely between, below, and above the meter bars.

The five subsidiary metres, the Committee metre, and the two bars supporting the thermometers, are placed horizontal and parallel, and the metres are supported independently on rollers at 0.211m from their ends towards the southern pier and on a cross-bar 0.211m from their ends towards the northern pier. Expansion and contraction of the bars will thus be measured mainly by the southern comparator. The trough is water tight, and the packing of the small cylindric ends of the bars projecting through the ends of the box is effected by a sheet of India rubber which is secured by a perforated brass plate. The trough rests on a carriage, which can readily be wheeled in on iron rails and brought to rest between the comparators for the successive measure of each metre. The tank is provided with a hot or cold supply pipe, emptying at the bottom of the trough, and with a waste or overflow pipe at the top; these pipes are of gutta-percha, and lead outside the comparing room, and are used in observations for determining the coefficient of expansion.

It is desirable to describe once for all the process of mounting and the adjustment of the comparators on any of the piers. A fine copper wire is stretched over the middle of the two piers and at right angles to the direction of the rails supporting the carriage with the bars. The comparators are placed on the piers, roughly, with their screws level and in the vertical plane of the wire, and at the proper height with respect to the end surfaces of the metre bars. The rails and bars are placed horizontal by spirit level; the brass bed plates of the comparators are leveled by means of four foot screws, and adjusted in height by means of a leveling instrument, so that the points of the contact pieces shall be precisely in a horizontal plane with the axis of the bar under comparison The comparators are made to read about the middle of their scales for average measure. Finally, after the screws of the comparators, the axes of their abutting pieces, and the centers of the small disks of the ends of the bar or bars under comparison, were all found in *the same straight and horizontal line*, the comparators were fastened down to the piers by means of plaster of Paris. No. 1 was always mounted on the northern, No. 2 on the southern pier, and increasing readings of screws correspond to decreasing distance between the central surfaces.

To obtain a measure of the stability of the piers, an additional metre was mounted on a wooden frame, supported at one-fourth of its length from the ends, and wrapped up in a woolen cloth and paper cover to protect it from sudden changes of temperature; it was always kept at the temperature of the room, and its thermometer scale could be read by opening a flap in the cover. For this purpose steel metre No. 19 was used, the same which serve for standarding the State metres; it is of the same section as the subsidiary metres and its length is given

$$\text{No. } 19 = \text{Com. met.} - 1^{\mu}.5, \text{ both metres at } 32^{\circ}.8 \text{ F.}$$

resulting from direct comparisons with the Committee metre in 1874, by J. J. Clark. In February, 1879, the same metres were compared by Assistant H. G. Ogden, and Sub-assistant H. W. Blair, who found respectively

$$\begin{aligned} \text{No. } 19 = \text{Com. met.} &- 11^{\mu}.5 \text{ at } 81^{\circ}.1 \text{ F. and } - 7^{\mu}.2 \text{ at } 60^{\circ}.8 \text{ F.} \\ &- 12^{\mu}.0 \text{ at } 81^{\circ}.1 \text{ F. and } - 7^{\mu}.1 \text{ at } 60^{\circ}.8 \text{ F.} \end{aligned}$$

Its coefficient of expansion was not determined, but it is now known from the above relative measures, and the absolute value for the Committee metre as given further on.*

Thermometer Green No. 8 is attached to this metre.

Immersed in glycerine was Kew thermometer (Hall mark) 966 and Kew thermometer (Hall mark) 968, the former near inflow, with bulb north, the latter near outflow, bulb south. The temperature of the room and of the comparators is indicated by the pier thermometers Tagliabue No. 517 on north pier and Tagliabue No. 512 on south pier. In all our comparisons the thermometers were used either in a horizontal or in a slightly inclined position.

The thermometric work depends for its accuracy on the corrections to the scales of the Kew thermometers Nos. 18411 and 35792; of the former the certificate was lost; of the latter it is given below. These thermometers were sent to the Physical Department of the Johns Hopkins University, Baltimore, and there re-standarded under the direction of Prof. H. A. Rowland, in October and November, 1880. The corrections refer to the instruments in *vertical* position, and depend on the indications of an air thermometer, they are:

Temp. (Fah.).	Correction to		Temp. (Fah.).	Correction to	
	18411.	35792.		18411.	35792.
°	°	°	°	°	°
32	—0.21	—0.13	70	—.11	—.05
35	.27	.14	75	.16	.10
40	.21	.14	80	.18	.16
45	.11	.15	85	.17	.18
50	.32	.18	90	.16	.13
55	.28	.18	95	.07	.07
60	.22	.13	100	.05	.06
65	—.18	—.07	105	—.05	—.05

*The above comparisons at three different temperatures give for the differential expansion -0.212^{μ} for each degree Fah. and for the length of No. 19 and of C. M. at the temperature t

$$\begin{aligned} \text{No. } 19 &= \text{C. M.} - 1^{\mu}.3 - {}^{\mu}.212\,(t - 32^{\circ}\text{ F.}) \\ &= \text{C. M.} - 1^{\mu}.3 - \ .381\ t\,\text{C.} \end{aligned}$$

hence in microns

$$\text{No. } 19 = 10^{6} - 1^{\mu}.3 + 6^{\mu}.338\,(t - 32^{\circ}\text{F.}) \text{ or } = 10^{6} - 1^{\mu}.3 + 11^{\mu}.408\ t\,\text{C.}$$

The Kew certificate for 35792 (Hall mark 969) gave for vertical position: Correction zero at 32°, 92° and 102°, and correction $-0^{\circ}.1$ at 42°, 52°, 62°, 72° and 82°.

Two series of thermometer comparisons were made by H. W. Blair, the first September 23 and 24, 1880, with the instruments vertical, and the second, December 16, 1880, with some instruments vertical, others horizontal; each series included thermometers 18411 and 35792 (vertical). These comparisons were made in a tank filled with water at different temperatures. All needful precautions were used in this elaborate work. The results are as follows, after the mean corrections due to 18411 and 35792 had been applied:

Kew thermometers horizontal.					Kew thermometers vertical.				
At	966	968	970	971	At	966	968	970	971
°	°	°	°	°	°	°	°	°	°
45.5 F.	−0.14	−0.24	−0.12	−0.12	42.0 F.	−0.06	−0.21	−0.09	−0.08
57.0	.20	.30	.20	.21	57	.08	.21	.11	.13
67.5	.13	.23	.13	.17	69	.07	.18	.13	.14
77.0	.14	.24	.16	.12	88	.07	.21	.13	.13
85.5	.16	.26	.16	.16	107	−.05	−.17	−.05	±.00
95.5	−.14	−.21	−.16	−.14					

N. B.—The Cassella numbers corresponding to the Hall marks are:

35789 to H. M.	966
35790	967
35791	968
35792	969
35793	970
35794	971

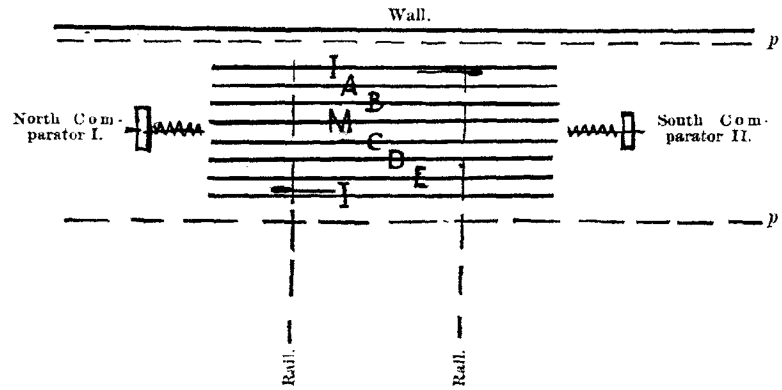
A series of comparisons made by H. W. Blair, December 10, 1880, gave the following corrections to thermometers J. Green Nos. 8 and 9 in horizontal position, depending on Kew standard H. M. 969 (or Cassella No. 35792) when vertical and corrected. The corrections to the pier thermometers Tagliabue Nos. 512 and 517 depend on comparisons made by F. H. Parsons, in August, 1880.

Corrections to graduations of thermometers.

	No. 8.	No. 9.		No. 512.		No. 517.
°	°	°	°	°	°	°
At 40.5 F.	−.00	−.02	At 45 F.	+.1	At 46 F.	−1.1
53.3	+.02	+.03	50	+.1	55	−1.0
63.8	+.07	+.07	55	+.1	65	−1.0
			60	+.1	75	−1.0
			65	.0		
			70	−.1		

ARRANGEMENT OF THE METRES IN THE GLYCERINE TROUGH.

The accompanying diagram shows the arrangement of the metres in their first position. M. is the Committee-metre and I I the iron bars to which the thermometers are attached; *p p* indicates the sides of the paper cage inside of which the comparisons were made. In position II the Committee-metre was inverted; in position III all the metres were inverted; and in position IV all the metres except M were inverted. Each position is used once with contact piece I, as in diagram; next the contact pieces of the comparators are exchanged. We thus obtain eight distinct results. Each set consists of the following operations: Reading of thermometers of metre No. 19; reading of pier thermometers; three comparator contacts taken in rapid succession; reading of thermometers of No. 19; reading of two thermometers in glycerine; three contacts of each metre-bar in succession; reading of thermometers in glycerine; three contacts of each of the six-metre bars in inverse order: reading of thermometers in glycerine; three contacts of No. 19 and



thermometers readings, closing with reading pier thermometers. Two sets were made each day, commencing about 9 a. m. and 2 p. m. The observations were made between December 11 and December 16, 1880, by H. W. Blair and F. H. Parsons. The results are as follows:

Subsidiary steel metres A, B, C, D, E, equal to Committee metre plus tabular quantity at given temperature.

TABLE I.

Arrangement.	At temp.	A	B	C	D	E
	F. °	μ	μ	μ	μ	μ
Position I						
1	54.82	+7.97	−10.42	+7.39	−11.71	−2.27
2	50.26	6.90	10.92	7.42	12.23	2.54
Position II						
1	52.13	10.69	7.43	9.61	8.53	1.67
2	52.89	9.81	9.40	8.37	11.16	−2.72
Position III						
1	54.32	10.83	7.95	10.23	8.17	+0.49
2	55.37	9.78	10.80	8.62	11.93	−2.06
Position IV						
1	56.65	8.29	10.09	10.28	12.05	2.99
2	57.33	+7.23	−11.10	+7.54	−13.45	−4.81
Mean	54.22	+8.94	−9.76	+8.68	−11.15	−2.30
Probable error in microns, and irrespective of differential expansion.	....	±0.37	0.33	0.29	0.44	0.34

The greater part of the probable errors arises from the imperfect end surfaces of the Committee metre, there being no definite points about its central axis.

Between the observations of the first table of results and the following one the several metres were subjected to various temperatures, from which their coefficients of expansion were deduced.*

The second series of observations were made February 3, 18 and 19, 1881, with some additional observations of metre C on March 2 and 3, 1881, by H. W. Blair and J. J. Gilbert.

* The Committee metre was also used in the interval by W. A. Rogers, of Cambridge, Harvard College Observatory, for some comparisons at Washington on his own comparing machine.

TABLE III.

Arrangement.	At temp.	A	B	C	D	E
	° F.	μ	μ	μ	μ	μ
Position I						
1	61.37	+13.47	−7.11	+7.66	−8.63	+0.30
2	61.40	15.84	3.43	10.07	6.26	+5.03
Position II						
1	61.59	9.39	10.52	5.53	11.77	+0.60
2	61.99	7.39	12.60	5.19	14.30	−3.99
Position III						
1	60.79	8.08	10.30	4.01	13.12	3.09
2	61.40	3.51	13.23	2.87	18.24	5.90
Position IV						
1	62.26	6.54	9.47	4.07	14.72	5.37
2	62.98	+6.65	−10.86	+4.02	−15.07	−4.02
Mean	61.72	+8.86	−9.69	+5.43	−12.76	−2.05
Probable error in microns and irrespective of differential expansion.	....	±0.95	0.76	0.56	0.91	0.89

Extra comparisons of M and C in air gave

Pos. I	59°.40 F.	+4μ.36
II	60 .40	6 .59
III	58 .65	10 .00
IV	59 .53	+4 .44

and when reduced to same temperature as in Table III + 4.00 + 6.34 + 9.56 and + 3.88

Mean	+ 5.94	$w=\frac{1}{2}$
by Table II	+ 5.43	$w=1$
adopted	+ 5.60 ± 0.46 μ	

The observations made for determining the coefficient of expansion yield three more values—all referring to the ordinary temperature of the room.

TABLE II *bis*.

Set.	Date.	Temp.	A	B	C	D	E
		° F.	μ	μ	μ	μ	μ
3	December 24, 1880	57.58	+ 7.5	−11.1	+ 8.0	−13.0	−2.1
6	December 27, 1880	52.60	+ 7.5	−12.0	+ 7.8	−13.3	−4.4
15	January 8, 1881	55.29	+ 9.8	− 8.7	+12.3	− 8.0	+0.2
	Mean	55.16	+8.27	−10.60	+ 9.37	−11.43	−2.10

The values of Tables I, II, III, may all be combined as possessing equal weight (the four results for C depending on comparisons in air are here excluded) since relative position of the metres appear to be of little consequence.

If we reduce all observed differences to the common or average temperature 57°.53 F. by means of the observed differential expansions and contractions as worked out in the next chapter* we obtain the following table of results.

*The coefficients of expansion of the steel metres A, B, C, D, E, were found to be nearly the same, but less by .00000023 than the coefficient of the iron metre M, hence for the reduction of the tabular differences we have −0μ.23 for each degree of Fah.

TABLE IV.—*Subsidiary metres A, B, C, D, E, equal to M + tabular quantity, the metres at 57° 53 F., or 14°.18 C.*

[All comparisons made in glycerine.]

Table.	Temp.	Δt.	A.	B.	C.	D.	E.
	° *F.*	°	μ	μ	μ	μ	μ
I.	54.82	+2.71	+ 7.35	−11.04	+ 6.77	−12.33	−2.89
	50.26	+7.27	5.23	12.59	5.75	13.90	4.21
	52.13	+5.40	9.45	8.67	8.37	9.77	2.91
	52.89	+4.64	8.74	10.47	7.30	12.23	3.79
	54.32	+3.21	10.09	8.69	9.49	8.91	0.25
	55.37	+2.16	9.28	11.30	8.12	12.43	2.56
	56.65	+0.88	8.09	10.29	10.08	12.25	3.19
	57.33	+0.20	7.18	11.15	7.49	13.50	4.66
II.	57.58	−0.05	7.51	11.09	8.01	12.99	2.09
	52.60	+4.93	6.37	13.13	6.67	14.43	5.53
	55.29	+2.24	9.28	9.22	11.78	8.52	−0.32
III.	61.37	−3.84	14.35	6.23	8.54	7.75	+1.18
	61.40	−3.87	16.73	2.54	10.96	5.37	+5.92
	61.59	−4.06	10.32	9.59	6.46	10.84	+1.53
	61.99	−4.46	8.42	11.57	6.22	13.27	−2.96
	60.79	−3.26	8.83	9.55	4.76	12.37	2.34
	61.40	−3.87	4.40	12.34	3.76	17.35	5.01
	62.26	−4.73	7.63	8.38	5.16	13.63	4.28
	62.98	−5.45	+7.90	−9.61	+5.27	−13.82	−2.77
Mean	57.53	Mean	+8.80	−9.87	+ 7.42	−11.88	−2.16
Probable error			± 0.44	± 0.38	± 0.33	± 0.43	± 0.43

A glance at the probable errors of the results from Table I and Table III shows the results of Table I to be far superior to the latter ones. Giving these eight results double weight the means and probable errors become as follows:

$$
\left\{\begin{array}{l}
A= M+ 8.61\ \mu\pm0.38\ \mu \\
B= M-10.06\ \mu\pm0.33\ \mu \\
C= M+ 7.57\ \mu\pm0.29\ \mu \\
D= M-11.89\ \mu\pm0.37\ \mu \\
E= M- 2.43\ \mu\pm0.37\ \mu
\end{array}\right.
$$

Σ or $A+B+C+D+E=5M- 8.20\ \mu\pm0.78\ \mu$; all metre bars at 57°.53 F, or 14°.18 C

b.—Determination of the coefficient of expansion of the Committee-metre and of the subsidiary steel. metres A, B, C, D, E.

For heating the glycerine a boiler was provided in the yard adjoining the comparing room, and for cooling the same a large tub was kept filled with ice; in this were placed tin vessels filled with glycerine and the whole was covered with pieces of ice. It was found that the flow of glycerine through the tubing leading to the comparing trough was too slow; it was therefore brought into the room in buckets and poured in the trough. The lowest temperature which could steadily be maintained during the time of making a set of comparisons was near 41° F., and the highest to which it was desirable to expose the bars was near 100° F. Special experiment was made December 18, 1880, to test the rapidity with which the steel bars immersed in glycerine would take up its temperature when markedly different from that of the room. It was found that with a sudden change of temperature of 22° F., the time elapsed before the micrometer readings became steady was twenty-two minutes; it was therefore concluded that observations could commence half an hour after the change of temperature had been made, by which time the axes of the bars had fully taken up the temperature of the fluid.

The method of observing was the same as explained before. The distance of the micrometers (or piers) was measured before and after each set of observations for coefficient of expansion by means of M 19; this metre-bar indicated the temperature of the room, and it was necessary in the first instance to assume a close value for its coefficient of expansion, in order to express the distance between the comparators. The coefficient usually taken before the present observations for M, was the value e=.00000642; from previous observations Δe of M and M 19 was found −.00000021, hence in the first computation e of M 19 was assumed .00000621. The observers were H. W. Blair and W. Suess; the observations commenced December 23, 1880, and were concluded January 8, 1881, during which time fifteen sets of comparisons were made, each consisting of five different mean temperatures and yielding each an independent value of e.

The distance of the piers or comparators resulting from contacts with m 19 is given in the following table, to which, however, 10^6 microns would have to be added.

December	23	Set 1	Temp. 55°.50 F.	d=405646.3 μ
	23	2	55 .95	650.3
	24	3	54 .29	648.7
	24	4	57 .44	651.9
	24	5	57 .67	656.6
	27	6	52 .75	640.5
	27	7	55 .39	640.6
	27	8	56 .95	647.4
	29	9	49 .01	616.7
	29	10	52 .87	615.6
January	3	11	42 .05	552.9
	7	12	54 .63	621.1
	7	13	58 .95	625.4
	7	14	57 .98	628.9
	8	15	54 .76	639.2

The distance between the comparators or rather between the piers is plainly variable and a function of the temperature. The values d being directly used in the computation for the various values of e, the latter are independent of any change in the distance d.

During these observations extraordinarily severe cold weather set in. On the morning (before daybreak) of December 31, 1880, the thermometer exposed to the night air indicated −14° F., the lowest temperature ever recorded at Washington (since January, 1820). The minimum thermometer in the comparing room showed 40° F.; the distance between the piers was shortened thereby nearly 100 microns.

This same distance between the comparators is also measured by the contact observations of each of the six metre bars, the latter being at various temperatures, and the differences of distance compared with the difference of temperatures gives the measure for expansion coefficient e; this for metre bar A we have, after putting the measured micrometer distance =D, the following table of results:

FIRST DETERMINATION OF e, METRE A.

Set.	Temp. t	D−10⁶	d−10⁶	d−D=Δ	$t-t_0$	$\Delta-\Delta_0$	Comp'd	$o-c$
	°F.	μ	μ	μ		μ		μ
1	99.08	405204.8	405646.3	+441.5	+28.13e=	+178.9	177.6	+1.3
2	83.68	307.4	650.3	342.9	+12.73	+ 80.3	80.4	−0.1
5	72.02	388.4	656.6	268.2	+ 1.07	+ 5.6	6.8	−1.2
3	57.58	472.8	648.7	175.9	−13.37	− 86.7	84.4	−2.3
4	42.39	567.4	651.9	084.5	−28.56	−178.1	180.3	+2.2
Mean	70.95=t_0			262.6=Δ_0				

Normal equation: 1948.92 e=12306.4 μ, e=6.315

SECOND DETERMINATION OF e, METRE A.

9	100.42	405162.5	405616.7	+454.2	+30.98e=	+201.6	198.5	+3.1
10	81.84	288.2	615.6	327.4	+12.40	+ 74.8	79.4	−4.6
8	69.94	392.6	647.4	254.8	+ 0.50	+ 2.2	3.2	−1.0
6	52.60	493.4	640.5	147.1	−16.84	−105.5	107.9	+2.4
7	42.39	561.3	640.6	073.3	−27.05	−173.3	173.3	0.0
Mean	69.44			252.6				

Normal equation: 2129.06 e=13638.5 μ, e=6.406.

THIRD DETERMINATION OF e, METRE A.

12	99.53	405176.5	405621.1	+444.6	+29.25e=	+187.0	185.5	+1.5
13	86.22	268.1	625.4	357.3	+15.94	+ 99.7	101.1	−1.4
14	68.92	381.1	628.9	247.8	− 1.36	− 9.8	8.7	−1.1
15	55.29	476.5	639.2	162.7	−14.99	− 94.9	95.1	+0.2
11	41.46	477.5	552.9	075.4	−28.82	−182.2	182.9	+0.7
Mean	70.28			257.6				

Normal equation: $2166.79\, e = 13745.9\ \mu$, $e = 6.344$

Similar computations were made for each of the other five metres, whence the following table of results of e for Fahrenheit scale, in microns:

	First.	Second.	Third.	Mean.
Metre A.	6.315	6.406	6.344	
B.	6.369	6.418	6.363	
M.	6.578	6.615	6.587	6.593
C.	6.367	6.414	6.393	
D.	6.353	6.400	6.324	
E.	6.330	6.417	6.274	

The whole of the computation was next corrected for the effect of the small difference in the assumed value of e of M 19 and the value now found, viz:

$$e(\mathrm{M}) = \quad 6.593$$
$$\Delta e(\mathrm{M\ and\ M\ 19}) = -0.212$$
$$e(\mathrm{M\ 19}) = \quad 6.381$$

This produced the corrected values of e(M) 6.576, 6.603, and 6.613, but there are five more values for e(M) determined in connection with the value of e for a zinc bar and arranged precisely in the same manner as the preceding record.

The observers were the same.

Final values for the coefficient of expansion of the Committee-metre or e (M).

1880, Dec. 23 to 24	6.576	
Dec. 27 to 29	6.603	Mean value e (M) = .000 006 550 for Fah. scale.
1881, Jan. 3 to 8	6.613	±14
Feb. 2 to 3	6.508	= .000 011 790 for C. scale.
Feb. 4 to 5	6.495	±25
Feb. 7 to 8	6.579	Hence, also, e (M_{19}) = .000 006 338 for Fah. scale.
Feb. 16 to 17	6.474	.000 011 408 for C. scale.

After the introduction of the last value, the expansions of the other metres become:

				Mean.	Prob. error.
Metre A	6.313	6.394	6.370	6.359 ±	0.017
B	6.368	6.406	6.389	6.388	0.008
C	6.366	6.403	6.419	6.396	0.012
D	6.351	6.389	6.350	6.363	0.007
E	6.329	6.405	6.300	6.345	0.019

The probable error of e(M 19) may be estimated at $\pm 0^{\mu}.016$
We now have:

$$\text{Length of Committee metre} = 10^6 + \underset{\pm 14}{6.550}\ (t - 32^\circ\ \mathrm{F.})\ \text{in microns}$$
$$= 10^6 + \underset{\pm 25}{11.790}\ (t - 0^\circ\ \mathrm{C.})$$

At 57°.53 F. or 14°.18 C. the Committee-metre equals $10^6+\underset{\pm .35}{167^\mu.20}$ and consequently the lengths of the metres A to E are at the temperature of 57°.53 F. or 14°.18 C., in microns

$$\left\{\begin{array}{l} A=10^6+175.81\pm.52 \\ B=10^6+157.14\pm.48 \\ C=10^6+174.77\pm.45 \\ D=10^6+155.31\pm.51 \\ E=10^6+164.77\pm.51 \end{array}\right. \quad \text{and at the temp. } t \left\{\begin{array}{l} A=1^m+\underset{\pm 52}{175^\mu.81}+\underset{\pm 17}{6^\mu.359}\,(t-57^\circ.53\text{ F.}) \\ B=1\ +\underset{\pm 48}{157^\mu.14}+\underset{\pm 8}{6^\mu.388}\,(t-57\ .53\text{ F.}) \\ C=1\ +\underset{\pm 45}{174^\mu.77}+\underset{\pm 12}{6^\mu.396}\,(t-57\ .53\text{ F.}) \\ D=1\ +\underset{\pm 51}{155^\mu.31}+\underset{\pm 7}{6^\mu.363}\,(t-57\ .53\text{ F.}) \\ E=1\ +\underset{\pm 51}{164^\mu.77}+\underset{\pm 19}{6^\mu.345}\,(t-57\ .53\text{ F.}) \end{array}\right.$$

$$\Sigma \text{ or } A+B+C+D+E=5^m+\underset{\pm 1.92}{827^\mu.80}+\underset{\pm 60}{31^\mu.851}\,(t-57^\circ.53\text{ F.})$$

$$\Sigma=5^m+\underset{\pm 1.92}{827^\mu.80}+\underset{\pm .108}{57^\mu.332}\,(t-14\ .18\text{ C.})$$

Where the first probable er equals $\sqrt{(5\times.35)^2+(.78)^2}$ and the second equals $5\times.012$
We have also

$$\Sigma=5^m+14.6\pm2.5 \text{ microns at } 32^\circ\text{ F.}$$

c.—Determination of the coefficient of expansion of a zinc and several brass metres, and other collateral results.

Steel metre No. 19.—The value of *e* for this metre was found $6^\mu.338$ for F. scale, and as it is of the same kind of iron as the five subsidiary metres we should expect a value near their average, viz, 6.370; their accordance is satisfactory. We have, also, from the observations December 11 to December 16, 1880, eight values of differences of length between Met. Com. and M 19, the former in glycerine, the latter in air, which give M 19 = Met. Com. $-\ 8^\mu.3\pm0^\mu.6$ at 54°.2 F., the computed value from other direct observations gives at that temperature $-$ 6.0 microns. The value for length of M 19, as given in a preceding foot-note, may be stated in the more convenient and complete form

$$\text{M } 19=1^m+\underset{\pm 37}{164^\mu.95}+\underset{\pm 16}{6^\mu.338}\,(t-58^\circ.23\text{ F.})$$
$$1^m+\underset{\pm 37}{164^\mu.95}+\underset{\pm 29}{11^\mu.408}\,(t-14\ .57\text{ C.})$$

Lenoir iron metre.—From observations made by H. G. Ogden and H. W. Blair in February and March, 1879, the differential expansion of this metre and of the Met. Com. was $-$ 0.165; hence, with the value of $e(\text{M})=\underset{\pm 14}{6.550}$ the value of $e(\text{L. M})=6.385$ and the expression for length of this metre

$$\begin{aligned} \text{L. M}&=\text{C. M}-\ 30^\mu.87+\ 6^\mu.385\,(t-59^\circ.68\text{ F.}) \\ &=1^m\ +\underset{\pm 37}{150^\mu.43}+\underset{\pm 16}{6^\mu.385}\,(t-59\ .68\text{ F.}) \\ &=1^m\ +\underset{\pm 37}{150^\mu.43}+\underset{\pm 29}{11^\mu.493}\,(t-15\ .38\text{ C.}) \end{aligned}$$

Results for coefficient of expansion e of a zinc and several brass metres.—Between February 2 and February 17, 1881, observations were made by Messrs. Blair, Suess, and Parsons for values of *e;* these operations were made in the same manner as for the steel metres. The work was undertaken by direction of the late Superintendent of the Survey. The zinc and the brass bars were cut to length, and provided at their ends with steel plugs, and placed side by side in the glycerine trough.

e Zinc bar (hard rolled):

1881.	Feb. 2–3	18.49 for 1° F.
	Feb. 4–5	17.86
	Feb. 7–8	18.11
	Feb. 16–17	18.51
	Mean value *e* =	18.24
		±.11

e. Brass bars of various compositions:

						Mean *e*
1881. Feb. 2–8	B 4, high brass	9.98	10.13	10.21	10.11 for 1° F.
	B 3, tough brass	10.12	10.01	10.29	10.14
	B 2, soldering brass	10.15	9.95	9.94	10.01
	B 1, yellow metal	10.51	10.50	10.55	10.52

Extremes of temp. during comparisons, 101° F. and 30° F.

d.—Determination of the coefficient of expansion of the five-metre standard bars Nos. I and II.

These bars are also designated Office standard and Field standard, respectively; they are of soft steel, and terminate in small hard steel cylinders of the same size as those of the steel metres (diameter 2½ millimetres, projection 1 millimetre). Permanently attached to them, at their ends, are two zinc bars, each of half the length of the steel bars, one on each side, with two Borda scales at the middle of each standard bar. These standards were mounted in a water-tight wooden box, painted with asphaltum, and further secured against the leakage of hot glycerine by a layer o plaster of Paris. The bars rested on 16 equidistant rollers, and the zinc bars on 8 independen rollers fitting over the same axes as those for the steel bars. The ends protrude through smal holes in a thin brass plate, and are secured by rubber diaphragms. Four thermometers were placed between the bars, immersed in glycerine to the depth of the axes of the bars, and, beginning with that near the north end, their Hall numbers were 966, 970, 968, and 971. The thermometers and Borda scales were read through glass windows in the lid of the box. When on the movable platform the box was surrounded by a thick layer of sawdust, in order to secure, as near as may be, a constant temperature of the glycerine during comparisons. The fluid was allowed slowly to run out through two orifices at opposite ends of the box, thus securing a slow but constant circulation of the glycerine. In all cases an interval of not less than 20 minutes was allowed to elapse after the temperature of the glycerine had become steady before commencing comparisons. Mounted on the same movable platform was a second wooden box containing the five metres, A, B, C, D, E, joined so as to form a length of 5 millimetres. The space between the boxes was filled with sawdust. During the work the system of the joined metres *exposed to air only*, was kept in a closed space, the temperature of which was ascertained by means of thermometers 479, 481, and 484, on the side towards the wall, and 480, 482, and 483 on the side towards the entrance; in both cases in the order from north end to south end. These instruments were read through glass windows in the lid. These 6 thermometers were received at the office in December, 1880; they were graduated by J. Green, of New York, in April, 1878, and had been filled six months. Careful comparisons were made by H. W. Blair of these instruments with Casella thermometers Nos. 18411 and 35792 (restandarded at the Johns Hopkins University, as mentioned above), and with Casella thermometers Nos. 21467 (the certificate of which was lost) and 35790, which two instruments had been sent to the Yale College Observatory for restandarding; for these Mr. L. Waldo, in charge of the Winchester Observatory of Yale College, gives the following table of corrections, the stems being *horizontal*:

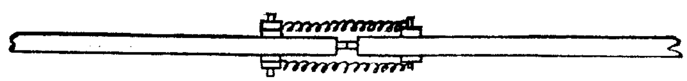
Temp. Fahr.	Thermometers.		Temp. Fahr.	Thermometers.		Temp. Fahr.	Thermometers.	
	21467.	35790.		21467.	35790.		21467.	35790.
°	°	°	°	°	°	°	°	°
32	−.29	−.12	52	−.32	−.23	72	−.18	−.02
34	.32	.16	54	.29	.22	74	.25	.05
36	.35	.20	56	.27	.10	76	.26	.04
38	.38	.23	58	.29	.11	78	.24	.04
40	.37	.25	60	.18	.11	80	.22	.05
42	.35	.25	62	.20	.13	82	.20	.06
44	.34	.25	64	.29	.14	84	.18	.07
46	.34	.23	66	.28	.10	86	.16	.07
48	.34	.17	68	.25	.05	88	.14	.08
50	−.34	−.16	70	−.24	−.02	90	−.12	−.09

The comparisons of the six Green thermometers with the four standards, made in water January 4 and 6, 1881, yielded the following results for the horizontal position of the thermometers 479 to 484.

THERMOMETERS, GREEN.

Temp.	479.	480.	481.	482.	483.	484.
° F.	°	°	°	°	°	°
41	+.12	+.10	+.15	+.19	+.30	+.25
49	.07	.10	.08	.15	.23	.17
61	.17	.20	.19	.20	.29	.19
72	.23	.23	.23	.22	.35	.23
83	.26	.28	.23	.24	.33	.23
96	+.38	+.38	+.33	.38	+.53	+.49

Each of the five joined metres rests on two rollers, at one-fourth of its length from the ends, and these are adjustable in height. Contact of the metre bars is assured by two spiral brass springs attached by clamps, one on each side, and on a level with the axes, to any two adjacent bars, as shown in the figure.

Steel metre.  Steel metre.

Spiral spring.

(The spiral springs were afterwards replaced by India-rubber bands.) The tension of the springs was regulated to be just sufficient to hold the system of bars together, without breaking contact when a gentle pull was applied to one of the end metres. The pivots of the end metres protrude through the closed ends of the box, and the whole system is carefully adjusted so that the axes of the comparators and of the five metres pull in the same horizontal right line. By means of the reflecting light of a candle held at one end, the eye at the opposite end could very accurately judge of the straightness of the polished upper surfaces.

The adjustment between the comparators (No. I at the north and No. II at the south pier) of the system Σ and Standards I and II being satisfactorily made, thirty-five sets of comparisons were secured between March 17 and March 26, 1881, yielding seven independent results for the coefficient of expansion of each of the standards. These observations were made by H. W. Blair and W. Suess. Each set consists of reading of all thermometers and Borda scales making contact with Σ, I, and II, and again with II, I, and Σ, and reading of all scales. To effect the reading of the Borda scales two plates of glass were laid over them, with the upper surface of the plates just above the level of the glycerine. A hand magnifying glass was used in reading off, the proper lenses not being ready.

The method of computation being the same as for the single metres, the results are given in a condensed form as follows:

No. of set.	Temp. t	Stand. I Δ	Stand. II Δ	No. of set.	Temp. t	Stand. I Δ	Stand. II Δ	No. of set.	Temp. t	Stand. I Δ	Stand. II Δ
	°	μ	μ		°	μ	μ		°	μ	μ
5	107.86	+2536.7	+2549.8	6	104.06	+2484.5	+2522.0	11	110.61	+2649.9	+2692.9
1	97.02	2254.0	2293.3	7	95.50	2215.8	2260.2	12	95.46	2238.2	2283.2
2	81.04	1762.3	1815.6	8	80.79	1742.0	1787.3	13	81.24	1765.4	1813.4
4	62.66	1136.6	1187.2	10	62.38	1152.8	1195.2	15	60.85	1081.5	1126.0
3	46.09	630.9	675.3	9	43.77	558.5	599.5	14	45.99	645.3	683.8
$t_0=$	78.93	1664.1	1704.2	$t_0=$	77.80	1630.7	1672.8	$t_0=$	78.83	1676.1	1719.9
	$e=$	6.261	6.175		$e=$	6.397	6.394		$e=$	6.314	6.326

Results—Continued.

No. of set.	Temp. t	Stand. I Δ	Stand. II Δ	No. of set.	Temp. t	Stand. I Δ	Stand. II Δ	No. of set.	Temp. t	Stand. I Δ	Stand. II Δ
	°	μ	μ		°	μ	μ		°	μ	μ
16	111. 47	+2717. 2	+2758. 4	21	111. 85	+2707. 5	+2743. 9	26	111. 86	+2739. 1	+2778. 0
17	91. 40	2084. 4	2124. 0	23	87. 09	1941. 2	1980. 8	27	97. 02	2282. 6	2324. 6
18	75. 45	1559. 7	1601. 4	22	75. 92	1587. 8	1628. 5	28	80. 22	1738. 6	1782. 8
20	62. 11	1113. 4	1153. 4	25	60. 03	1054. 5	1095. 8	30	60. 77	1081. 8	1120. 3
19	43. 38	518. 9	567. 7	24	44. 66	586. 8	623. 6	29	42. 18	538. 9	567. 9
$t_0=$	76. 76	1598. 7	1640. 9	$t_0=$	75. 91	1575. 6	1614. 5	$t_0=$	78. 41	1676. 2	1714. 7
	$e=$	6. 484	6. 465		$e=$	6. 346	6. 342		$e=$	6. 380	6. 408

No. of set.	Temp. t	Stand. I Δ	Stand. II
	°		μ
31	108. 16	+2594. 6	+2630. 6
32	95. 25	2219. 8	2259. 9
33	79. 79	1720. 0	1768. 5
35	59. 35	1032. 4	1071. 9
34	43. 44	527. 3	547. 7
$t_0=$	77. 20	1618. 8	1655. 7
	$e=$	6. 448	6. 489

The first of the seven determinations was not as satisfactory as the others; hence I gave it the weight one-half; hence

$$e \text{ Office or No. 1 standard} = 6.384 \pm .018$$
$$e \text{ Field or No. 2 standard} = 6.386 \pm .023$$

and for centigrade scale the coefficient:

$$e \text{ (Standard I)} = .000\,011\,491 \pm 32$$
$$e \text{ (Standard II)} = .000\,011\,495 \pm 41$$

e.—Determination of the coefficients of expansion of the zinc bars forming, in connection with the steel bar, the metallic or Borda thermometer of Standards I and II.

The Borda scales of the Office standard are lettered A and B, and those of the Field standard C and D; in the following computation the mean readings are used, and designated $\frac{A+B}{2}$ and $\frac{C+D}{2}$, respectively. The expansion of the zinc bars is had from the differential expansion of steel and zinc, as read off on the Borda scales (one division=1mm and read by verniers to 0.01d) and from the observed total expansion of the steel bars, using the preceding observations, we first arrange the Borda scale readings and the corresponding temperatures, beginning with the mean of the seven highest temperatures (of the preceding seven sets) and ending with the mean of the seven lowest temperatures. By the process of taking differences of the individual values from the mean, we deduce the value in divisions of the scales corresponding to a change of 1° F. in the bars.

Mean temp. Stands. I, II.	Mean scale $\frac{A+B}{2}$	Mean scale $\frac{C+D}{2}$	$t-t_0$	$\Delta\frac{A+B}{2}$	$\Delta\frac{C+D}{2}$		Computed. $\Delta\frac{A+B}{2}$	Computed. $\Delta\frac{C+D}{2}$
°			°	d	d	Treating the observed values for change in Borda scale corresponding to change of temperature of 1° F., or $\Delta\frac{A+B}{2}:(t-t_0)$ and $\Delta\frac{C+D}{2}:(t-t_0)$	d	d
109. 41 F	8. 60	8. 65	+31. 79	+0. 92	+0. 90		+0. 93	+0. 93
94. 11	8. 17	8. 25	+16. 49	+0. 49	+0. 50		+0. 48	+0. 48
79. 21	7. 74	7. 82	+ 1. 59	+0. 06	+0. 07		+0. 05	+0. 05
61. 16	7. 16	7. 23	−16. 46	−0. 52	−0. 52		−0. 48	−0. 48
44. 22	6. 72	6. 78	−33. 40	−0. 96	−0. 97		−0. 98	−0. 97
t_0=77. 62	7. 68	7. 75						

By the method of least squares, we obtain from the normal equations

For Standard I	$78^{d}.05 : 2671.54 = 0^{d}.02922$ or change of $\frac{A+B}{2}$ for 1° F.	=	$29^{\mu}.22$
For Standard II	$77\ .92 : 2671.54 = 0\ .02917$ $\quad\frac{C+D}{2}$		$29\ .17$

Also,

$$\text{Change of Borda scale } \frac{A+B}{2} \text{ for change of } 1^{\circ}\ C = 52^{\mu}.60$$

$$\text{Change of Borda scale } \frac{C+D}{2} \text{ for change of } 1^{\circ}\ C = 52\ .51$$

A change of $0^{d}.01$, the least scale reading, corresponds roughly to about $\frac{1}{3}$° F. or $\frac{1}{5}$° C. change in the temperature of the bars.

The effective length of each zinc bar is 249cm. Hence, differential expansion of zinc and steel for 1m equal to $11^{\mu}.735$ and $11^{\mu}.715$; and, adding the steel expansions $6^{\mu}.384$ and $6^{\mu}.386$ for Standards I and II, the zinc expansions or the sum of these numbers become

For Standard I	$18^{\mu}.119 \pm 0^{\mu}.049$
For Standard II	$18\ .101 \pm 0\ .051$

where the probable errors are derived from computation of the seven individual values.

The relation of the Borda scale indications to the length of the standard bars may also be given, viz:

A change of 0.01 division of the Borda scales $\left(\frac{A+B}{2}\right)$ corresponds to a change in length of Standard I, $\frac{5 \times 6.384}{2.922}\mu = 10^{\mu}.92$ and for Standard II, $\frac{5 \times 6.386}{2.917}\mu = 10^{\mu}.94$

The differences A−B and C−D may be used as indicating the condition of the standards with respect to unequal exposure to heat. For rough comparisons the Borda scales may be used, but for refined work the mercurial thermometers permanently attached must be employed.

f—Determination of the coefficients of expansion of four steel and two zinc bars which entered afterwards in the construction of the base bars.

For this purpose the six bars which had previously been supplied for temporary use with steel abutting plugs, were placed side by side and parallel to one another, in the same box or trough in which the two standards had rested during similar work. The bars were supported on eight rollers and were immersed in glycerine, the temperature of which was ascertained by six thermometers, viz: Nos. 966, 8, 970 on the east side, and Nos. 968, 9, 971 on the west side of the bars. The absolute distance between the comparators was obtained by the combined five metres of the system Σ, which always remained at the natural temperature of the room. After the glycerine was either heated or cooled, the comparisons did not commence until the glycerine had remained for half an hour at a stationary temperature. The bars were arranged in the order S_{I} Z_{II} S_{III} for Base Bar I, and S_{IV} Z_{V} S_{VI} for Base Bar II, the first system of bars being nearest to the wall. The observations were made by Messrs. Blair and Gilbert between April 1 and April 8, 1881. The results of e expressed in microns for length of 1m and referring to Fahrenheit scale are as follows:

Values of e of steel bars and of zinc bars.

	S i	S iii	S iv	S vi	Z ii	Z v	
Series I	6.532	6.563	6.567	6.522	*18.309	17.929	W = ¼
II	6.520	6.544	6.581	6.555	17.771	17.825	
III	6.577	6.623	6.618	6.550	17.751	17.722	
IV	6.526	6.567	6.574	6.516	17.731	17.724	
V	6.528	6.591	6.588	6.550	17.739	17.770	
VI	6.545	6.586	6.602	6.558	17.737	17.718	
Mean	6.538	6.579	6.588	6.542	†17.746	17.760	
Prob. error	± 6	8	5	5	± 5	14	
Mean	6.557 ± 7		6.565 ± 5				

*Rejected. †Weighted mean.

The extreme temperatures of the glycerine and bars were 115°.18 F. and 41°.76 F.

The results given suppose linear expansion, but it was found that for the zinc bars a term depending on the square of the difference of temperature was needed; the coefficient of this second term for the steel bars was insensible.

Treating the following data by the method of least squares, we find

Mean. temp. t	Zinc bar ii Δl	Zinc bar v Δl
° F.	μ	μ
111.79	4993.7	4299.2
96.58	3630.6	2961.0
77.04	1813.7	1143.0
60.09	339.3	−326.8
42.25	−1191.1	−1860.6
t_0=77.55	+1917.2	+1243.2

For zinc bar $_{ii}$ $\dfrac{dl}{ldt}=+17.850$ and $\dfrac{d^2l}{ldt^2}=+.012$

For zinc bar $_{v}$ 17.789 +.010

The residuals when expressed in degrees of Fahrenheit are, respectively

$+0^\circ.1$ for bar $_{ii}$ and	$+0^\circ.2$ for bar $_{v}$
−0.3	−0.4
+0.2	+0.3
0.0	0.0
−0.1	−0.1

The above low values of e when compared with the values found for the bars attached to the standard may possibly be explained by the individual character of the bars, but are of little consequence since the length of the base bars is made to depend directly on the length of the field standard.

g—First determination of the length of the five-metre Standard Bars I and II.

Before commencing the comparisons each standard was deposited in its own box for permanent keeping. The five joined metres or the system Σ was directly compared with the standards; the three tight boxes containing the respective bars being mounted on the movable platform, and each carefully adjusted. Their order was, beginning with that nearest to the east wall Σ, I, II. All comparisons were made in air, the natural temperature of the comparing room was as little interfered with as possible; with Σ there were six thermometers (479, 480, 481, 482, 483, 484); with I, there were three (966, 8, 968); and with II, there were three thermometers (970, 9, 971) all horizontal or nearly so, and read through glass windows in the lids of the boxes. It was aimed at to secure one-half of all observations with rising, and the other half with falling temperature. The five single metres were variously combined by the following arrangement: No two faces of metres and comparators came in contact more than once; each face came in contact with eight others, and the faces were presented in different positions, *i. e.*, with respect to up and down. If we number the faces of the metres from north to south, beginning with A at Comparator I and ending with Σ at Comparator II in their order of position with 1, 2, 3, etc., so that for instance 7–8 refers to the ends of metre D, the following arrangements were made:

1–2	3–4	5–6	7–8	9–10	and	2–1	3–4	6–5	7–8	10–9
9–10	7–8	5–6	3–4	1–2		10–9	7–8	6–5	3–4	2–1
3–4	9–10	5–6	1–2	7–8		4–3	9–10	6–5	1–2	8–7
7–8	1–2	5–6	9–10	3–4		8–7	1–2	6–5	9–10	4–3

The above eight arrangements were doubled by inverting* every second and fourth bar. First, the bar Σ, next I, next II, were brought between the comparators, then again II, I, Σ, all thermometers and Borda scales, being read before and after Σ was moved in position. The observations were made by Messrs. Blair and Weir, between April 22 and May 2, 1881, and between the hours of noon and 11 p. m.

In the computation we take $\Sigma = 5\text{m} + \underset{\pm 1.92}{827^{\mu}.80} + \underset{\pm 60}{31^{\mu}.851}\,(t - 57^{\circ}.53\ \text{F.})$, and for the total expansion of either I or II for 1° F. the number $31^{\mu}.925$ as found before.

Date.	Comb'n No.	Temp. t of Σ	Σ at t 5m +	I > Σ	I = 5m +	at temp. t_1 (F.)	I −5m at 68°.75 F.	II > Σ	II = 5m +	at temp. t_{II} (F.)	II −5m at 68°.90 F.
1881.		°	μ	μ	μ	°	μ	μ	μ	°	μ
April 22	1	65.92	1095.0	122.6	1217.6	65.66	1316.2	188.4	1283.4	65.89	1379.2
22	2	67.56	1147.3	104.5	1251.8	66.96	1308.9	184.3	1331.6	67.44	1378.2
23	3	66.04	1098.9	113.7	1212.6	65.85	1305.2	182.8	1281.7	66.06	1372.4
23	4	67.14	1133.9	104.6	1238.5	66.67	1304.9	179.2	1313.1	66.97	1374.4
27	5	70.10	1228.2	116.0	1344.2	69.72	1313.2	178.4	1406.6	69.71	1380.7
27	6	70.82	1251.1	105.5	1356.6	70.25	1308.7	171.2	1422.3	70.40	1374.4
28	7	69.76	1217.3	121.9	1339.2	69.52	1314.6	184.1	1401.4	69.51	1381.6
28	8	70.70	1247.3	106.0	1353.3	70.14	1308.9	177.1	1424.4	70.28	1380.3
28	9	70.62	1244.7	113.2	1357.9	70.32	1307.8	179.2	1423.9	70.31	1378.6
28	10	71.73	1280.1	107.1	1387.2	70.[illegible]	1317.9	179.1	1459.2	71.09	1389.2
29	11	70.26	1233.3	118.8	1352.1	69.97	1313.2	184.0	1417.3	69.93	1384.4
29	12	71.39	1269.3	106.6	1375.9	70.61	1316.5	182.5	1451.8	70.74	1393.1
30	13	68.84	1188.0	116.0	1304.0	68.64	1307.9	181.3	1369.3	68.60	1378.6
30	14	69.86	1220.5	104.9	1325.4	69.26	1309.1	180.0	1400.5	69.38	1385.2
May 2	15	67.90	1158.1	106.4	1264.5	67.26	1312.1	180.4	1338.5	67.43	1385.1
2	16	69.34	1204.0	94.9	1298.9	68.26	1314.5	178.1	1382.1	68.60	1391.7
	Mean	69.25		Mean	1311.2	68.75	1311.22	Mean	1381.7	68.90	1381.70
							±0.69				±1.02

*Top down.

Hence from the above comparisons

Length of Office or No. I standard$=5m+1311^{\mu}.22+31^{\mu}.920\ (t-68^{\circ}.75\ F)$
$\pm.69 \quad \pm 90$

Length of Field or No. II standard$=5m+1381.70+31^{\mu}.930\ (t-68^{\circ}.90\ F)$
$\pm 1.02 \quad \pm 115$

To these probable errors must be added the probable errors arising from the bringing up of the temperature of the system Σ from 57°.53 F. and that of Σ itself, but these will best be considered in connection with the final values for length of standards.

We note for future comparison mean reading of Borda scales of Standard I or $\frac{1}{2}(A+B)=7^{d}.466$, and of Standard II or $\frac{1}{2}(C+D)=7^{d}.516$, corresponding to 68°.75 and 68°.90 F. of temperature as indicated by the mercurial thermometers; these readings correspond also to the respective length of I and II as given above.

Increasing scale readings signify increasing length of bars.

h—Determination of the corrections to the thermometers permanently attached to the standard bars and to the base bars.

One dozen centigrade mercurial thermometers were ordered from J. Green, of New York, and received in April, 1881. They are divided to half degrees; the divisions etched on the glass tube; they range from about -20° C. to $+50^{\circ}$ C. They were filled in 1878 and graduated six months after filling. The comparisons were made in water by Mr. Blair, and the results depend on the four Casella standards Nos. 18411 and 35792 in *vertical* position, and Nos. 21467 and 35790 in *horizontal* position, all others in *horizontal* position. The new Green thermometers are numbered 4516, 4517, 4518, 4519, 4520, 4522; these with the four standards were first compared May 5 and 6; the other six Green thermometers are numbered 4523, 4524, 4525, 4526, 4527, 4528, were next compared May 9 9nd 10 with the same standard, and in addition 4519 of the first set was again used but in *vertical* position; of these thermometers 4516 and 4517 were attached to Standard I, 4518 and 4520 to Standard II, 4522 and 4523 to Base Bar I, and 4524 and 4525 to Base Bar II; the corrections are as follows:

Table of corrections to twelve centigrade thermometers (Green 4516 to 4528) all in horizontal position, and 4519 also in vertical position.

Temp. C.	4516.	4517.	4518.	4519.	4519 vert.	4520.	4522.	4523.	4524.	4525.	4526.	4527.	4528.
°	°	°	°	°	°	°	°	°	°	°	°	°	°
43	−.33	−.33	−.33	....	−.25	−.36	−.36	−.40	−.34	−.34	−.32	−.32	−.37
38	.26	.28	.26	....	.27	.28	.28	.26	.26	.29	.26	.25	.26
32.5	.27	.32	.30	−.34	.24	.30	.33	.24	.24	.32	.28	.22	.24
27	.28	.29	.28	.28	.22	.29	.30	.24	.20	.30	.26	.20	.26
21.5	.15	.15	.18	.15	.18	.13	.19	.18	.13	.20	.17	.13	.22
16	.20	.14	.16	.14	.12	.11	.23	.16	.13	.12	.16	.10	.14
10	.19	.06	.16	.09	.12	.06	.15	.16	.06	.12	.14	.06	.09
4.5	−.15	−.02	−.06	−.08	−.15	−.02	−.08	−.11	−.07	−.10	−.12	−.06	−.08

i—Second determination of the length of five-metre Standard No. I.

First series.—These observations were made between February 13 and March 18, 1882, by W. Suess and E. B. Lefavour; there were the same sixteen different arrangements of the single metres A to E as in April and May, 1881, but after half of them had been made the system Σ and Standard I were exchanged in position, the latter being now east of Σ, also Standard I was turned end for end. Thermometers 479 to 484 were in the box of system Σ as before, 479, 481, 484 being on the east side of the metres. Thermometers 4516 and 4517 were with Standard No. I. The bars were brought between the comparators in the order No. I, Σ, Σ, No. I, and after eight sets were completed, in the order Σ, No. 1, No. 1, Σ. To prevent changes of temperature due to convection currents the boxes containing the bars were filled with raw cotton; each set of comparisons consists of two independent series of measures.

Date.	Comb'n No.	Temp. t of Σ.	Σ at t 5m +	Stand. I > Σ	Stand. at temp. $t_{,}$	Sets combined.	Stand. I −5m at $t_{,}$	$t_{,}$
1882.		° *F.*	μ	μ	° *C.*			° *C.*
Mar. 18	1	58.28	851.7	85.6	14.22	1 and 9	999.0	15.33
Feb. 14	2	68.22	1168.3	106.5	20.02	2 and 10	1143.8	17.94
15	3	67.10	1132.6	97.1	19.33	3 and 11	1089.6	17.08
16	4	66.60	1116.7	99.5	19.11	4 and 12	1040.3	16.18
17	5	68.07	1163.5	110.9	19.98	5 and 13	1104.0	17.14
18	6	63.78	1026.9	93.8	17.46	6 and 14	1102.8	17.04
20	7	60.22	913.5	88.0	15.38	7 and 15	1080.2	16.68
21	8	62.30	979.7	89.2	16.48	8 and 16	1131.8	17.56
Mar. 13	9	61.00	938.3	122.5	16.44	Mean	1086.4	16.87
14	10	59.66	895.6	117.1	15.87			
15	11	57.78	835.8	113.7	14.84			
Feb. 27	12	55.24	754.9	109.5	13.24			
28	13	57.16	816.0	117.7	14.29			
Mar. 1	14	61.56	956.2	128.8	16.63			
2	15	63.67	1023.4	135.6	17.98			
3	16	64.86	1061.3	133.3	18.64			
	Mean	62.22 *F.* =16.79 *C.*			16.87			

Second series.—These observations were made between May 22 and June 10, 1882, precisely like those of the preceding series. Observers, W. Suess and J. G. Porter.

Date.	Comb'n No.	Temp. t of Σ	Σ at t 5m +	Stand. I > Σ	Stand. at temp. $t_{,,}$	Sets comb'd.	Stand. I −5m at $t_{,,}$	$t_{,,}$	The two series combined. Stand. I −5m at mean temp.	at $\frac{1}{2}(t_{,}+t_{,,})$	Stand. I −5m at t_0
1882.		° *F.*	μ	μ	° *C.*		μ	° *C.*	μ	° *C.*	μ
May 22	1	71.88	1284.9	112.8	21.80	1 and 9	1368.8	21.72	1183.9	18.52	1220.1
23	2	71.06	1258.7	113.1	21.54	2 and 10	1365.5	21.67	1254.6	19.80	17.3
24, 26	3	69.88	1221.1	72.4	20.84	3 and 11	1317.4	21.12	1203.5	19.10	06.4
25	4	70.56	1242.8	115.1	21.26	4 and 12	1340.0	21.09	1190.2	18.64	19.5
27	5	68.48	1176.5	106.9	20.10	5 and 13	1300.0	20.44	1202.0	18.79	22.7
29	6	70.46	1239.6	112.7	21.24	6 and 14	1355.7	21.32	1229.2	19.18	27.5
31	7	70.06	1226.9	105.8	20.97	7 and 15	1375.5	21.64	1227.8	19.16	27.2
June 1	8	71.37	1268.6	111.6	21.78	8 and 16	1428.3	22.45	1280.0	20.00	31.2
2	9	70.52	1241.5	98.5	21.64	Mean	1356.4	21.43	1221.4	t_0=19.15	1221.4
3	10	71.06	1258.7	100.5	21.80						±1.8
5	11	70.06	1226.9	114.3	21.40						
6	12	69.30	1202.7	119.5	20.92						
7	13	69.15	1197.9	118.6	20.78						
8	14	70.30	1234.5	124.6	21.40						
9	15	71.95	1287.1	131.2	22.32						
10	16	73.54	1337.7	138.7	23.12						
	Mean	70.60			21.43						

Five metre standard No. I = 5m + 1221μ.4 + 57μ.457 (t − 19.15 C.)
±1.8 ±.162

j—Recomparison of five-metre Standards Nos. I and II, the Field or No. II Standard having been returned from California November 1, 1882.

Before making these observations the lower ventilator of the comparing room was more effectively closed, the narrow spaces between the floor and the several piers were covered with pieces of carpet, and the whole of the north wall of the room was hung with blankets. During the measure of the Yolo base the five-metre Field standard was wrapped in felt; hence the Office standard was likewise covered with blanketing and canvas. The comparisons were made each day at 9^h, noon, and 3^h. After each observation the positions of the bars were exchanged with respect to front and back (on the platform). At the close of the eighth day of observations both bars were turned end for end; position I, Office standard, back, thermometer 4516 north; Field standard, front, thermometer 4520 north. After exchange the comparisons were continued eight days more, with the usual reversals. Observers, Messrs. Chapman and Porter.

In order to eliminate the effect of different exposure of the bars with respect to position the results are combined by pairs, as shown below. The fact that the Field standard is longer than the Office standard is indicated by II > I.

1883.		First day.	Second day.	II > I.	$t_{\prime\prime}$	$t_{\prime}$	1883.		First day.	Second day.	II > I.	$t_{\prime\prime}$	$t_{\prime}$
		μ	μ	μ	C.	C.			μ	μ	μ	C.	C.
Jan. 15, 16,	9^h	94.2	52.3	73.2	10°.25	10°.19	Jan. 24, 25,	9^h	81.7	39.5	60.6	12°.12	12°.01
	12	63.0	60.1	61.6	10 .26	10 .53		12	58.6	56.2	57.4	12 .08	12 .02
	3	70.5	65.2	67.8	10 .60	10 .62		3	65.7	50.9	58.3	12 .15	12 .12
17, 18,	9	96.5	55.1	75.8	10 .92	10 .82	26, 27,	9	75.4	44.9	60.2	12 .32	12 .27
	12	66.8	67.4	67.1	11 .28	11 .27		12	66.7	51.4	59.0	12 .39	12 .36
	3	76.5	57.2	66.8	11 .62	11 .54		3	65.1	47.1	56.1	12 .50	12 .48
19, 20,	9	73.1	47.4	60.2	13 .19	13 .10	29, 30,	9	71.0	51.4	61.2	13 .49	13 .46
	12	58.3	54.0	56.2	13 .40	13 .40		12	60.3	52.0	56.2	13 .60	13 .61
	3	61.9	58.6	60.2	13 .58	13 .58		3	59.3	53.2	56.2	13 .82	13 .86
22, 23,	9	79.7	57.6	68.6	13 .16	13 .08	Jan. 31, Feb. 1,	9	64.4	43.6	54.0	15 .12	15 .14
	12	70.9	52.8	61.8	13 .08	12 .98		12	60.1	41.9	51.0	15 .22	15 .28
	3	67.5	67.6	67.6	13 .08	13 .01		3	68.0	47.0	57.5	15 .34	15 .40
				Mean	12 .03	12 .01					Mean	13 .35	13 .33

Combining next the first result II > I with the last, the second with the last preceding one, etc., we have

	II>I	$t_{\prime\prime}$	$t_{\prime}$		II>I	$t_{\prime\prime}$	$t_{\prime}$	Comb'n.	Mean II>I	Mean $t_{\prime\prime}$	Mean $t_{\prime}$
	μ	C.	C.		μ	C.	C.		μ	C.	C.
1	65.4	12°.80	12°.80	7	58.2	12°.84	12°.79	1 and 7	61.8	12°.82	12°.80
2	56.3	12 .74	12 .90	8	57.6	12 .90	12 .88	2 and 8	57.0	12 .82	12 .89
3	60.9	12 .86	12 .88	9	60.2	12 .95	12 .92	3 and 9	60.6	12 .90	12 .90
4	66.0	12 .37	12 .34	10	63.4	12 .66	12 .60	4 and 10	64.7	12 .52	12 .47
5	61.6	12 .44	12 .44	11	59.6	12 .58	12 .50	5 and 11	60.6	12 .51	12 .47
6	64.0	12 .56	12 .50	12	64.1	12 .60	12 .51	6 and 12	64.0	12 .58	12 .50
								Mean	61.45 ±.77	12 .69	12 .67

$$\text{Standard II} - \text{Standard I} = 61^{\mu}.4, \text{ supposing both bars at } 12^{\circ}.68 \text{ C.}$$
$$\pm 0.8$$

k—Recomparison of Nos. I and II with the five metres A, B, C, D, E joined.

In this series of comparisons each standard was treated independently, and after each set of comparisons the standard and the joined system A to D, or Σ, were exchanged in position, as in the preceding work. It was noticed that the variations made in the position of the single metres had but little influence upon the resulting length; the metres forming Σ were therefore placed in position 5, which they occupied April 27, 1881, and which corresponded most nearly with the average length from all the combinations made. This combination is: Comparator I to the left, B, E, C, A, D; Comparator II to the right. After four days of comparisons, made at the hours 9, 12, and 3 of Standard I with Σ, Standard II was substituted for the former, and four days of comparisons were made. System Σ was then turned end for end, and its metres E and A were inverted.* Standard II was likewise turned end for end and four days of comparisons made; II was then removed, and I put in its place, turned end for end, and compared four days, thus completing eight days for each bar. Observers were Mr. Chapman and Mr. Porter. The ther-

* Top down.

mometers 479, 480, 481, 482, 483, 484 were attached to Σ, 4516, 4517 to I, and 4518, 4520 to II. Series commences with I back and Σ front.

Office standard longer than 5m.							Field standard longer than 5m.						
					$t_,$	t of Σ						$t_,$	t of Σ
1883.		µ	µ	µ	C.	F.	1883.		µ	µ	µ	C.	F.
Feb. 9, 10,	9h	1048.1	1042.5	1045.3	16°.77	62°.06	Feb. 14, 15,	9h	1152.7	1157.1	1154.9	16°.24	61°.09
	12	48.8	45.2	47.0	16 .86	62 .20		12	60.6	61.6	61.1	16 .36	61 .67
	3	55.2	44.8	50.0	17 .00	62 .66		3	55.7	56.8	56.2	16 .55	61 .98
12, 13,	9	1044.4	1048.9	1046.6	16 .06	60 .80	16, 17,	9	1156.5	1169.9	1163.2	17 .24	63 .18
	12	54.4	52.9	53.6	16 .13	61 .15		12	53.3	63.9	58.6	17 .59	63 .71
	3	57.8	48.7	53.2	16 .30	61 .40		3	62.4	60.0	61.2	17 .78	64 .22
24, 26,	9	1044.4	1040.6	1042.5	15 .74	60 .20	19, 20,	9	1153.1	1145.0	1149.0	16 .98	62 .24
	12	43.1	55.7	49.4	15 .82	60 .47		12	51.9	52.1	52.0	17 .02	62 .52
	3	50.9	51.2	51.0	15 .95	60 .79		3	58.5	50.2	54.4	17 .12	62 .84
27, 28,	9	1041.1	1048.1	1044.6	15 .48	59 .68	21, 23,	9	1153.7	1149.6	1151.6	16 .86	62 .08
	12	43.4	44.4	43.9	15 .54	59 .84		12	54.0	52.4	53.2	16 .82	62 .30
	3	49.1	45.3	47.2	15 .64	60 .16		3	55.0	56.2	55.6	16 .91	62 .50

$$\text{Where } \Sigma = 5\text{m} + 827^{\mu}.80 + 31^{\mu}.851\,(t - 57^{\circ}.53\ \text{F.})$$

Combining first results with last, second with last less one, etc., we have

No.	Stand. I at 16°.11 C.	$t_,$	t	Δ t	No.	Stand. II at 16°.96 C.	$t_{,,}$	t	Δ t
	µ			C.		µ			C.
1	5m+1046.2	16°.20	16°.17	°.03	1	5m+1155.2	16°.58	16°.56	°.02
2	45.4	16 .20	16 .12	.08	2	57.2	16 .61	16 .66	.05
3	47.3	16 .24	16 .21	.03	3	53.9	16 .70	16 .68	.02
4	48.8	16 .00	16 .00	.00	4	58.8	17 .18	17 .28	.05
5	51.5	15 .98	16 .01	.03	5	55.3	17 .30	17 .29	.01
6	47.8	16 .02	16 .03	.01	6	55.1	17 .38	17 .35	.03
Mean.	5m+1047.8	16 .11	16 .09	.02	Mean.	5m+1155.9	16 .96	16 .96	.00
	±.6					±.5			

The column headed Δt shows that the temperature was controlled within the limit of 0°.03 C.

Standard I at 16°.11 C=5 metres+1047µ.8
±.6
Standard II at 16°.96 C=5 metres+1155µ.9
±.5

l—Combination of the several values determining the length of the standards and their final length.

The comparisons of 1881, April 22 to May 2, are equivalent to comparisons of the difference of length of the standards and to a determination of an average standard ½ (I+II). We have accordingly II−I at 68°.90 F. and +68°.75 F.=70µ.48, and reducing to the mean temperature II−I at 20°.46 C=65µ.7±1µ.2 The second expression ½ (I+II) at 20°.46 C=5m+1346µ.5±0µ.9 was found to differ nearly 19 microns from all other results, equivalent to nearly one-third degree C. defect in the temperature of the system Σ, and since the position of this box relative to the wall was not changed, I have thought it best to reject the result.

We therefore have the following results:

1881 April	22 to May 2	at 20°.46 C	II−I=65µ.7±1µ.2		(1)
1882 May	22 to June 10	19 .15	I	=5m+1221µ.4 ±1µ.8	(2)
1883 January	15 to February 1	12 .68	II−I=61µ µ.8		(3)
1883 February	9 to February 28	16 .11	I	=5m+1047µ.8 ±0µ.6	(4)
1883 February	14 to February 23	16 .96	II	=5m+1155µ.9 ±0µ.5	(5)
		t_0=17 .07			

If we refer these results to the average temperature t_0 by means of the known coefficients of expansion they become

				p.
$II-I=65^{\mu}.6\pm1^{\mu}.2$	hence the conditional		$0=+65.6+l_{I}-l_{II}$	0.7
$I=5m+1101.9\pm1.8$	equations and		$0=+1101.9-l_{I}$	0.3
$II-I=61.5\pm0.8$	weights p after		$0=+61.5+l_{I}-l_{II}$	1.6
$I=5m+1103.0\pm0.6$	putting $I=5m+l_{I}$		$0=+1103.0-l_{I}$	2.8
$II=5m+1162.2\pm0.5$	and $II=5m+l_{II}$		$0=+1162.2-l_{II}$	4.0

The normal equations are $\begin{cases} 0=-3274.6+5.4\,l_{I}-2.3\,l_{II} \\ 0=-4793.1-2.3\,l_{I}+6.3\,l_{II} \end{cases}$ hence $\begin{cases} l_{I}=+1101^{\mu}.78 \\ l_{II}=+1163.05 \end{cases}$

also e_0=probable error of an observation of unit weight$=\sqrt{\frac{.455[pvv]}{m-n}}$ where m=number of observation and n=number of normal equations, hence

$$e_0=\pm1.75 \text{ microns.}$$

To find the probable errors of l_{I} and l_{II} we form the weight equations and get the reciprocals of the weights 0.22 and 0.19 respectively, hence probable error of $l_{I}=1.75\sqrt{.22}=\pm0.82$ and of $l_{II}=1.75\sqrt{.19}=\pm0.76$ microns. To these probable errors must yet be added the probable error of the system Σ viz, the probable error of the length of Σ or $\pm1^{\mu}.92$ and the probable error arising from bringing up the system from its temperature 14°.18 C to 17°.07 C or $\pm.108\times2.89=\pm0^{\mu}.31$

Therefore whole probable error of each standard $\sqrt{(.79)^2+(1.92)^2+(.31)^2}=\pm2^{\mu}.1$ and finally the resulting length of the standards:

Standard No. I or Office standard$=5m+1101^{\mu}.8+57^{\mu}.46\,(t-17°.07\text{ C})$
$\pm2.1 \quad \pm.16$

Standard No. II or Field standard$=5m+1163^{\mu}.0+57.47\,(t-17.07\text{ C})$
$\pm2.1 \quad \pm.21$

DETERMINATION OF LENGTH OF THE FOUR-METRE STANDARD, IRON ROD NO. 1, BY MEANS OF THE FIVE-METRE OFFICE STANDARD AND A SINGLE METRE.

In connection with the standarding of the new five-metre bars I propose to make a new and entirely independent determination of the length of the old iron four-metre standard, which has been used for many years, and is still so used for the standarding of our four-metre base apparatus. This was also desirable in order to secure perfect accord in the triangulations depending on different base lines and forms of apparatus. (For the same reason some comparisons with the six-metre standard were made.)

Rod No. 1 and steel metre E were abutted together and adjusted level and in a straight line with the axes of the comparators. Metre bar E was in a box by itself, and its ends protruded through paper screens forming the ends of the box. It was supported on two rollers, as in preceding work. Two thermometers, J. Green, 479 and 480, were put in the box and read through glass-covered windows in top of it. The thermometers were horizontal, and their corrections have already been given. Contact between E and the four-metre rod was secured by two spiral springs just pressing hard enough to secure surface contact. The four-metre rod was in its own box, and its temperature was determined by the thermometer accompanying it. Special comparisons made by Mr. Blair, May 18–19, 1881, with standards 18411 and 35790, used heretofore, gave the following corrections:

At 37° F.	−0°.23;	at 74° F.	−0°.10
50	−0 .26;	86	−0 .10
62	−0 .16;	100	−0 .13

Parallel to this system, and on the same platform, was mounted five-meter standard No. 1, supplied with thermometers 966.8 and 968, used heretofore; it was adjusted as usual. The observations for difference of length were made by H. W. Blair and J. B. Weir on May 4 and on June 21 1881, with E. B. Lefavour in place of Mr. Weir. The latter observations were made at night, and thermometers 4516 and 4517 were then used with standard No. 1. The order of comparisons was five-metre standard No. 1, the system four-metre standard No. 1 plus metre E, and again the five-metre standard Thermometers were read off before and after each set of comparisons.

The immediate result from five sets of comparisons on May 4, 1881, is:

4m standard No. 1=5m standard No. 1—meter E—$311^{\mu}.0$
at $66^{\circ}.59$ F. at $66^{\circ}.51$ F. at $66^{\circ}.26$ F.

The five sets of comparisons on June 21, 1881, give:

4m standard No. 1=5m standard No. 1—metre E—$308^{\mu}.7$
at $76^{\circ}.60$ F. at $24^{\circ}.70$ C. at $76^{\circ}.13$ F.

In June and August, 1882, two more determinations of the length of the four-metre standard were made, viz, June 20, 22, and 26, W. Suess and J. G. Porter observers, 12 sets; and August 9, 11, and 12, D. C. Chapman and J. G. Porter observers, 12 sets. The single metre B was used in the place of E.

The results are:

4m standard No. 1=5m standard No. 1—metre B—$370^{\mu}.0$
at $78^{\circ}.84$ F. at $25^{\circ}.83$ C. at $78^{\circ}.92$ F.

and

4m standard No. 1=5m standard No. 1—metre B—$357^{\mu}.8$
at $78^{\circ}.36$ F. at $25^{\circ}.72$ C. at $78^{\circ}.25$ F.

Introducing the known length of the five-metre standard and of metres E and B, we find:

Comparisons of May 4, 1881	four-metre standard at $66^{\circ}.59$ F.=4m+$691^{\mu}.4$	
June 21, 1881	four-metre standard at 76 .60 F.=4m+942 .4	
June 20, 22, 26, 1882	four-metre standard at 78 .84 F.=4m+941 .4	
August 9, 11, 12, 1882	four-metre standard at 78 .36 F.=4m+951 .5	
	Mean value 75 .10	881 .7

We also have, from comparisons made in February, 1877, by Mr. Blair, the revised result:

1877	four-metre standard at $13^{\circ}.89$ C.=4m+$442^{\mu}.8$
1881 and 1882	four-metre standard at 23 .94 C.=4m+881 .7
Mean	four-metre standard at 18 .92 C.=4m+662 .3

The value of 1877 depends upon metres Nos. 1, 19, 35, 38, which were compared with the Committee metre. The method and means of comparison of 1877 were different from those of 1881–'82.

DETERMINATION OF LENGTH OF THE SIX-METRE OFFICE STANDARD BY MEANS OF THE FIVE-METRE OFFICE STANDARD AND A SINGLE METRE.

Four sets of comparisons were made of the six-metre standard No. 1 with the five-metre standard No. 1 + metre B. The circumstances under which these observations were made were unfavorable, in consequence of the confined space, which required the bars to be placed diagonally in the comparing room. This produced a difference of temperature near the two ends of the bars, one end, in the northeast corner, being exposed to the effect of the outer temperature, the other end, in the southwest corner, being exposed to the interior temperature of the building. Nevertheless, the mean result for length agreed well with former determinations, although the coefficient of expansion which may incidentally be derived comes out smaller than found by direct observations in 1860.

The results reached in 1882 are as follows:

Set.	Date.	Length of 6m standard No. 1.	At temp.
1	Aug. 25 to Sept. 4	6m+$1647\mu.8\pm3\mu.1$	$76^{\circ}.67$ F.
2	Sept. 16 to Sept. 6	+1451 .6 3 .6	71 .24
3	Oct. 14 to Oct. 25	+1208 .3 3 .3	64 .65
4	Dec. 11 to Dec. 19	+ 878 .9 5 .6	55 .90
	Mean	6m+$1296\mu.6\pm1\mu.8$	67 .11 F.

The coefficient of expansion of 1860 was .00000641; hence reduction to 0° C. = $-1350^{\mu}.5$ and
± 2 ± 4.2
length of six-metre standard at the temperature of melting ice.

$$6m - 53^{\mu}.9 \pm 4^{\mu}.6$$

With this value we may compare the values found in 1860 by Assistant Hilgard, viz, $6m - 59^{\mu}.3 \pm 0^{\mu}.8$ and that of 1870 by Assistant Blair, viz, $6m. - 45^{\mu}.3 \pm 2^{\mu}.5$

The accord, therefore, is sufficiently close.

REMARKS ON THE LENGTH OF THE BASE-BARS NOS. 1 AND 2.

Since the length of these bars must in every case depend upon the direct observations with the Field standard at the time of the measure of a base, it would be useless to make an accurate determination at the office. They were standarded, as near as may be, to five metres.

APPENDIX No. 8.

REPORT OF THE MEASUREMENT OF THE YOLO BASE, YOLO COUNTY, CALIFORNIA.

By GEORGE DAVIDSON, Assistant.

The development of the "Davidson quadrilaterals" looked to obtaining a base-line in that part of the Sacramento Valley lying immediately east of the Vaca or Berryessa Mountains; and after the selection of the stations "Vaca Mountain" and "Monticello" an examination was made for the location.

Vaca Mountain station commands the whole flat country to the east of it, but Monticello does not overlook the whole of these plains on account of a peak of nearly the same elevation standing a short distance to the southeast of the station.

The streams and sloughs running eastward from the Berryessa Mountains, which form the western boundary of the Sacramento Valley, are usually short and not very large. But in the rainy season they carry large volumes of water, with swift currents, and are subject to overflows. These overflows have gradually raised their banks from some distance on either side, so that the stream may be said to run on a ridge. Cache Creek (Rio Jesus Maria), having the great equalizing reservoir of Clear Lake as its source, does not present this last feature in a marked degree, but Putah Creek (Rio de las Putas), Anderson, Dry, and Willow Sloughs do. The sloughs which are dry and grassy in summer and fall are bank-full in winter, and even overflow. The banks of Dry Slough are very markedly higher than the adjacent land. These stream ridges lie nearly east and west, and therefore cross the line of any base chosen parallel to the Berryessa Mountains.

Under instructions of the Superintendent, I commenced the examination of the plains of Yolo County between Cache and Putah Creeks for a suitable base-line, in April, 1876, having with me Assistants Rockwell and Eimbeck. After familiarizing myself with the country for a few days, and locating special objects, I easily located a 6-mile base-line lying east and west midway between Cache and Putah Creeks, and then obtained a proper quadrilateral, with its longest diagonal parallel to the line Vaca Mountain–Monticello.

Further examination proved that not only this longer diagonal of the quadrilateral was available for a base-line, but also that another of the sides of the quadrilateral could be had. Upon representing the facts to the Superintendent, and showing that the long line would obviate the occupation of two extra stations on the plains, which would be required if either short base was adopted, he accepted the long base by telegraph.

Fortunately, there is a ridge of 35 feet elevation lying on the south side of Cache Creek bottom. This gave favorable elevation to the north end. At the southern end of the base on Putah Creek the land is low, and, fortunately, *Monticello* comes out from behind an outlying peak. Half a mile northward of the Putah the station Monticello is invisible.

Within eight days the whole question had been settled. Assistant Eimbeck was then detailed to erect signals at Vaca Mountain and Monticello stations, both somewhat difficult of access. Assistant Rockwell was detailed to make a plane table survey with telemeter from Northwest to Southeast base station, so as to determine the relative positions of houses, fences, improvements, sloughs, etc. In this work he made the length of the base 17 573½ metres by telemeter rod. The wheat was then 4 feet high and the measurements not easily made.

When this was about finished I received instructions to occupy stations Mount Diablo and Mount Helena on the scheme of work to extend eastward, and north and south, and to connect with the primary work along the coast.

In 1878 I was ordered to Europe to examine the instruments of precision at the Paris Exhibition.

In 1879 I occupied the stations Mount Lola and Round Top, in the Sierra Nevada.

In 1880 I occupied the stations Southeast Yolo base, Northwest Yolo base, Monticello, and Vaca Mountain.

In June of that year I instructed Sub-Assistant Dickins to make a new topographical survey of the line of the base to ascertain what improvements had been made upon it. His length differed 10 metres from Mr. Rockwell's. Both lengths were obtained by telemeter.

I studied the wearing of the banks of the Putah Creek, which had been cutting the left bank badly to the east of the Southeast base, and the right bank badly above the Southeast base.

For various reasons I moved the Southeast base station about 300 yards westward of the provisional station of 1876. The location of the Northwest base was not changed.

The line appears to avoid all the probable improvements for some years at least, but as it passes through a very rich tract of wheat country, it must eventually be occupied.

As the high ridge of Willow Slough lies directly across the line, I decided to build a brick shaft 30 to 35 feet above the ground at Southeast base, and one of 15 feet elevation at Northwest base. These piers are elsewhere described. The Southeast base station is about 25 metres from the left bank of the Putah Creek, and the ground is 23 feet above low water therein. There is a slight levee between the bank and the station, with a post and board fence thereon.

GENERAL LOCATION OF THE YOLO BASE-LINE.

The line is in Yolo County, in the Sacramento Valley, and nearly midway between the Sacramento River and the Vaca or Berryessa Mountains. (See sketch No. 28.) It lies nearly parallel with the California Pacific Railroad, joining the towns of Davisville and Woodland (county seat), and between 3 and 4 miles west therefrom. Its general direction is N. 16° 53′ W., and S. 16° 53′ E. The south end lies in the northwest quarter of section 19, township 8 north, range 2 east, Diablo meridian, being $3\frac{1}{8}$ miles west and $1\frac{1}{8}$ miles south of Davisville. It is reached by taking the county road west from Davisville and turning southward on the unopened road which is a south continuation of the Plainfield road. The land is owned by W. H. Soule, post-office Davisville, Yolo County, California.

The north end lies in the extreme southeast corner of the southeast quarter of section 28, township 10 north, range 1 east, Diablo meridian, being $4\frac{1}{3}$ miles west of the railroad passing through Woodland, and immediately on the north side of the county road running west towards Madison and Copay Valley. The land is owned by Mr. Jefferson Wilcockson, of Sacramento, but now rented by Mr. William Gibson, living one mile south of Woodland; there is no fence around the land. On the opposite side of the road is Mr. James Oliver's ranch. He is familiar with all the operations here and was heliotroper in 1880. His post-office is Woodland.

The land immediately west of the base-line is a little higher, but between that higher ground and the foot-hills there is a general depression parallel with the line of the mountains and the base. Just west of the northern part of the line the land is rolling, whilst on the east it is quite thickly filled up with farm-houses and the large groves around them. From Willow Slough southward the soil is very good, and this part is largely occupied by farm-houses and large surrounding groves. In a very few years improvements will doubtless cover the line.

MARKING THE BASE STATIONS.

In June, 1880, upon the final location of the two ends of the base, they were marked before the occupation of the stations with the 20-inch theodolite, as shown in sketch No. 29.

The soil at Southeast base is a very fine sand, with an admixture of clay, but not sufficient to cause it to be designated other than a fine sandy soil, formed from the material deposited by overflows of the Putah Creek. It is easily worked with the spade and does not require the pick.

The elevation of the pier was such that it required a large foundation, and this was projected at 70 inches square and 50 inches below the surface, to be built of well-burned brick, with cement. The sketch shows the general proportions of this pier and base. Below this base, however, there was placed a granite block 12 inches, squared on top, and 2 feet 11 inches deep, with a somewhat irregular base of 20 inches. This was a truncated pyramid, irregularly square. The top of this stone reached within 4 inches of the base of the main work, and was wholly separated from it. The base of it was in cement, placed in the lower excavation. On the the top was deeply cut the legend as shown in sketch. The marking for station point was on a flat-headed round copper bolt, 5 inches long and five-eighths inch diameter. The head was turned with a flat spherical surface, $1\frac{5}{8}$ inches diameter, and into the top was inserted a German-silver wire. In the polished end of this wire was punctured, with a needle, a fine hole about one-twenty-fourth inch in depth (by estimation). This mark was transferred to the surface by means of a finely turned $4\frac{1}{2}$-pound plummet, hung carefully over it, and examined by a magnifier. Then meridian instrument No. 1 was placed on its brick stand at the transit and latitude observatory, at right angles to the base line, and a 6-inch Gambey theodolite on the line to the northward, nearly on line of base. The foot-screws of the meridian instrument were removed and the base cemented to the pier and adjusted, and the fine plummet thread brought between the middle thread and the micrometer thread, which had been moved close thereto. Mr. Gilbert adjusted the theodolite and brought the X-threads on the plummet thread. Then Mr. Colonna placed four stubs around the station, two east and west, two north and south. In each pair of copper nails fine points were pricked, in line with the plummet thread and the meridian instrument and the theodolite. These marks were for tests and checks, lest the instruments should be disturbed.

Over the copper bolt in the subsurface block, a nearly hemispherical glass about 3 inches in diameter was placed, and the earth then tamped around it to the level of the ground upon which the base of the brickwork was to rest.

The work for the brick foundation then commenced by wetting the soil at the bottom of the excavation, spreading a good layer of cement thereon, and working it well to establish its connection with the soil. Brick courses were carried up 14 inches solid and 70 inches square; then the pier was battered and brought to receive the surface block of granite 26 inches square by 25 inches deep; upon this being properly placed, the brickwork carried to the surface with sides of 54 inches. This work was then allowed to stand for twenty-four hours, when the surface-mark for the station was made. This marking is on the upper surface of a copper bolt, which was set in lead and then driven until the head was battered out nearly even with the surface of the stone, polished and burnished. Then a minute hole was made in the copper at the intersection of the lines from the instruments; after which cross-lines were made with a penknife merely as guides to find the hole. Into this mark was stuck a fine needle, placed vertical, and all was then covered with a glass tumbler, and the work on the *hollow* pier was commenced.

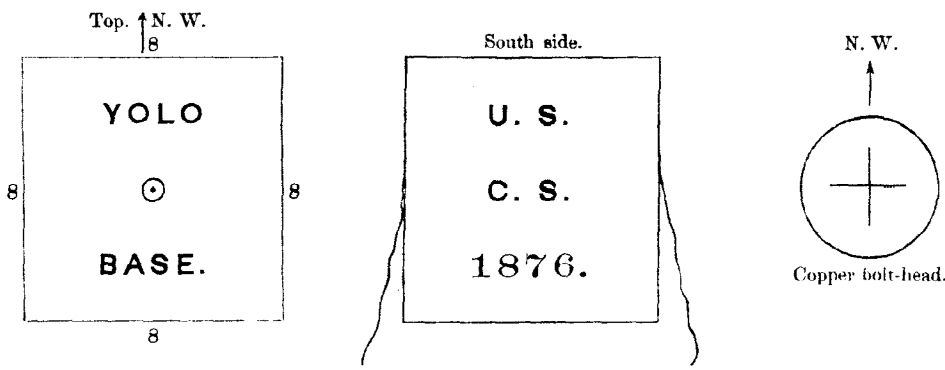
The pier is here 54 inches square, with a hollow shaft $16\frac{1}{2}$ inches square (to the top). To see the mark, two sight channels were left in the pier, one from the hollow center towards the meridian instrument, and one from the hollow center towards the theodolite. A wooden box with trap-door on top protected the glass and mark from falling mortar, etc.

In filling in earth around the subsurface part of the structure four barrels of *charcoal and charcoal dust*, which had been burnt for the purpose, were mixed with the earth in tamping.

The pier was carried $33\frac{1}{4}$ feet above the surface, and upon its top was laid a granite slab 40 by 40 by 8 inches, with a hole $1\frac{1}{4}$ inches diameter in the center. Upon this granite slab, after the pier had set, the position circle and theodolite were centered by means of the instruments already referred to. Subsequently, to provide against the possibility of the pier getting a cant during wet weather, etc., four reference marks were established to recover the station. These are especially referred to on page 142. This precaution was proven to have been necessary after the rainy season of 1880-'81.

The making of the Northwest base station was almost identical with that of the Southeast base. The same character of granite blocks, masonry, etc., was used; and the same methods of marking and reference. The soil at this station is a moderately stiff clay below the surface, and had to be picked out. When it was replaced around the brickwork two barrels of charcoal were mixed with the earth in tamping.

It should be mentioned that when the base-line was measured the extremity of a bar projected 1.96 metres beyond the base station. To mark the end of this bar, one of the "fence stones" was placed in the ground, with its surface even with the top of the soil. Into the top of this stone block was leaded a copper bolt, with a small mark in it, to denote the point from which the fraction of a bar was measured. The top of this stone is marked:



REFERENCE MARKS FOR SOUTHEAST BASE STATION.

(Sketch No. 6.)

To provide means for restoring the station in case of the tower taking a lean during the time it was allowed to stand after the horizontal directions and azimuths had been measured, Assistant Colonna was detailed in December, 1880, after leaving Vaca Mountain station, to place sub-surface marks, below the reach of the plow, on the line of the base northward, and at right angles thereto eastwardly, which he did, as per sketch.

To place the subsurface structure of brick in cement, a hole for each was dug 3 by 3 by 3 feet; then two courses of bricks were laid in cement; then a cube of granite, one foot each side, was set on this. In the upper surface a copper bolt was set, leaded, and driven in solid. The brickwork was then carried up and around the stone three bricks square on the outside. Each block is 1¼ feet high and the tops are 18 inches below the surface.

To mark the bolt in the granite cube, meridian instrument No. 1 was placed over No. 2 block, and its center marked by a drill-hole in the top of the copper bolt. Then the instrument was directed to the station, and a drill-hole made in bolt No. 1 on the line. The meridian instrument was then placed over No. 3 block. The copper bolt was marked in the same manner as No. 2 bolt had been, and then the instrument was directed to the station, and the No. 4 bolt was marked by drill-hole in the line. All were tested repeatedly. The bolts Nos. 1 and 3 were protected by drinking-glasses turned over them; around each glass, cement was placed to form a hard setting for them, but was prevented from adhering to the stone by placing a sheet of paper under the cement. Nos. 2 and 4 had not this protection. The granite block of No. 2 cracked when the bolt was driven home solidly.

The zenith telescope and transit piers, being on the line No. 1–No. 2, were removed to the lowest two courses, which are 18 inches below the surface, as rough references only.

THE BASE LINE LEVELED AND MEASURED WITH FIFTY-METRE WIRE.

When I was occupying the stations Southeast base and Northwest base with the large theodolite, Assistant Colonna was detailed to run a line of levels and repeat between the two stations, and then to connect the Northwest base with the California Pacific Railroad bench-mark at Woodland. Fifty-metre telegraph wire was compared with a Chesterman steel tape on top of a straight level fence.

In measuring, the ground passed over was either high stubble or summer fallow. The wire was strained 48 pounds by a spring balance at the forward end. A stub was driven in the ground at every 50 metres, and a tack driven in top of the stub.

The following measures were made:

	Metres.
349 measures, 50 metres each	17450
1 measure, 25 metres	25
1 measure, 50 feet	15.24
Base	=17490

The count was checked by levelings as follows: The level instrument was each time set over a pin, and the rods held on a stub; this gives 100 metres to each station, unless otherwise noted. Thus, check

	Metres.
159 stations by 100 metres	15900
1 station by 150 metres	150
13 stations by 100 metres	1300
1 station by 50 metres	50
3 stations by 25 metres	75
1 station by 15.24 metres	15.24
Base	=17490

The levels were run over the base-line twice. The two rods, Boston pattern, were kept plumb by means of a plumb-bob attached to each. One rod was held over the back stub, and the other over the forward stub, and the readings were made as nearly simultaneously as practicable.

The rods had been compared with a standard yard and found practically correct.

	Feet.
The first measurement, from southeast base to northwest base, gave for the difference of level	81.931
The second, from northwest base to southeast base	82.122
Mean difference of level	82.026

The levelings between northwest base and Woodland, California Pacific Railroad bench-mark were

	Feet.
I. From northwest base to Woodland	92.698
II. From Woodland to northwest base	92.669
	92.683

The railroad bench-mark, as given by the railroad engineers, is 60.6 feet above mean low water of San Francisco Bay. Therefore we have, provisionally

Southeast Yolo base station = 71.257 feet above low water, San Francisco.

Northwest Yolo base station = 153.282 feet above low water, San Francisco.

The plan I had in view to determine this satisfactorily was to connect the Southeast base station (via Dixon and railroad) with the Coast and Geodetic Survey bench-mark at Benicia by a line of levelings to be carried out this winter.

TEMPORARY MARKS ON BASE-LINE.

After studying the different methods of marking the points on the base when the work closed at night, at lunch, and at the approach to a bridge, I adopted a granite block 12 by 12 by 4 inches, with a copper bolt five-eighths inch diameter projecting two inches above surface, with its end double beveled and silvered. On one face of this dull knife-edge a small fine line was drawn from the edge downwards. This line was the point of reference. When the "mark" was to be fixed in position a hole was scraped in the soil to a depth of 3 or 4 inches, and the block placed in it. The knife-edge was placed in the line of the bar, and the fine line approximately located under the end of the bar.

An ivory scale divided to 0.50mm was then placed in line with the bar, and a given division of the scale—for instance, 20.00mm—was made coincident with the fine line by means of a magnifier. The scale was made level. Then, with the sector, the end of the bar was transferred to the scale. After some progress, the method adopted with the sector was to level the transit axis, point on bar, and read the scale once; then reverse the transit axis level, adjust and point on end of bar, and read the sector again; then reverse the telescope in the Y's, level transit axis, point on end of bar, and read scale; reverse transit axis level, adjust and point on end of bar, and read scale. At each reading the ivory scale was reset.

The sector was placed a distance of nearly 20 feet from the end of the bar and at right angles thereto. The magnifying power of the telescope was measured 20 diameters. The legs of the tripod of the sector were cut short, so that the height of the telescope was about 3 feet above the ground. This enabled the end of the bar and the metre scale to be seen with the same focus of the telescope. Three of these granite marking-blocks were in use, so that no block was removed until another, or a kilometre block ahead, had been established. After some progress of the work, I adopted the rule of using the sector always on one side of the bars.

THE MOVABLE COVER FOR THE BASE APPARATUS.

Having determined to measure the base-line with the beams and trestles carrying the base-bars protected from the direct action of the sun, I gave to Assistant Gilbert a general idea of what I wished, and the cover was constructed under his direction at Sacramento.

To protect the bars from the direct action of the sun, to secure them from injury at night, or during any temporary suspension of the measurement, and to allow ample room for movement during work on both sides of the trestles and bars, it was necessary to have a cover 50 feet long, 12 feet wide, and 9 feet high, one that should possess great strength and yet be light enough to be easily moved by two or three men.

The foundation was a parallelogram of the length and width just named; the material was Puget Sound fir, and the size of the timbers $2\frac{1}{2}$ by 6 inches; the angles were strengthened by heavy three-eighths-inch angle-irons and stout bolts. The canvas cover was stretched over wagon bows of ash, spliced so as to obtain the necessary width and height.

Four wheels were used, each having a diameter of $3\frac{1}{2}$ feet, and each pair secured $10\frac{1}{2}$ feet from the end, in such a way that they could be readily detached and the frame-work allowed to rest on the ground. This was always done during any temporary suspension of the measurement, and at night the cover was completely closed by canvas curtains and secured so as to afford entire protection to the apparatus against wind and rain. The whole cover complete weighed about 1,200 pounds, and on hard, level ground could be moved by one man.

When at work, the standard bar No. 2 was carried secured to the rail on the shady side of the cover. Suitable shelves and bags served to hold such tools, instruments, etc., as were needed from time to time during the progress of the work; thus loaded the wheels doubtless sustained a weight of 1 500 pounds. The entire frame-work is fastened together with ordinary carriage bolts, and can be readily taken apart for shipment. The movable cover became known throughout the region as the "Yolo buggy."

THE ORGANIZATION OF THE PARTY.

The readiest way of understanding the movement of the party at work is by an examination of the annexed plan (Sketch No. 30), exhibiting the bars and tripods or trestles in position, and the traces of the men's forward movements.

As we actually reached an average of fifty-seven bars per hour, and frequently several consecutive bars in forty-five seconds each, it will be readily understood that the whole of the movements must have been almost as regular as machinery. Every officer and man had a specific duty assigned to him, and no deviation was allowed therefrom. The general forward movement may be said to commence at the command "Break," when the contact slide of the forward bar was drawn back, and the after bar was drawn back, lifted out, and moved forward. The tripod men relieved the tightening of the legs, picked up the tripods, and moved forward, where the tripods were put in line and in position by an officer; the plates followed and were placed outside the position of the legs; then the tripods were placed on the plates, accurately distanced, leveled, and clamped. The "buggy" moved forward as soon as the plates were raised. One officer, near the sector, guarded the bar which remained in position. An officer then received in his own hands the after end of the forward bar, and was then responsible for it until the next "break" of contact.

The details of aligning the bar, raising or depressing the after end, making approximate contact, reading the Borda and mercurial thermometers, reading the sector, and making final contact under a magnifier, fell into their regular and necessary sequence.

It was the duty of each officer to guard against errors of reading scales and thermometer; of the recorder, to announce any seeming deviation from regularity of change; and of the chief, to call for any re-examination if he suspected mistakes.

The sector readings for inclination were checked by a re-reading; and in the second measurement one officer read the sector and left it without announcing his reading until the second officer had given the degrees and minutes.

It will be noticed that the bars were carried forward on one side of the line of tripods, officers and plate and tripod men remaining on the other, and no one was permitted to pass under the bars. When no actual measurement was being made, and when the night or bench-mark or any other mark was being referred to, all hands left the inside of the "buggy" until recalled.

At the close of the day the bars and standard were put in position on the comparing beam, resting on two trestles for the morning comparison, and lightly covered with canvas against rain beating through the light cover. At night the watchman had a hammock swung under the "horse" or trestle over the wheels.

Before the measurement commenced the bars were compared with the standard bar, in the condition in which they had remained over night; then the sectors were examined by the leveling instrument for the determination of the zero of the inclination arc. The after bar was then plumbed over the night mark, and at its satisfactory measurement the command "Break" announced the forward movement of the bars. The night mark was covered by a box and left intact until another mark had been secured.

It will be seen by the plan that the following personnel of the party was requisite on the ground:

Chief of Party Davidson, Assistant Gilbert, Sub-assistants Dickins, Pratt, Blair, Recorder Hill, Mechanician Suess	7
Men, 11; watchman, 1; driver (and extra, who also attended to bridges, etc.), 2	14
In camp: cook, officers' steward, men's steward	3
Total, officers and men	24

FOOT PLATES OF THE TRESTLES.

These plates were devised as a substitute for those with circular groovings, the latter being too limited in their range. The plate herewith exhibited in section and plan was found to answer all the purposes demanded. (See Sketch No. 29.)

The plates were laid independently of each other, and with very little practice the men became familiar with the best mode of stamping them down. They were used on every character of ground, and had their severest test on that part of the line torn open by innumerable "drying cracks," as mentioned in this report. Each plate weighed 9¼ pounds, and the points were turned steel riveted on top. There were none of them broken or injured in the work.

COMPARISONS OF THE BASE BARS WITH THE FIELD STANDARD BAR.

I had brick piers built at Southeast base, Middle base, Northwest base, and Camp Schott, upon which to place the frame made by Mr. Suess, in camp, for carrying the two base bars and standard bar during comparison. Independent piers carried the comparators. All the earlier comparisons were made on this frame and piers at camp and at Southeast base.

Having determined to make comparisons of the base bars and standard every morning before commencing measures, I directed Mr. Pratt to make a portable wooden beam, which should rest on two ordinary trestles. Upon each end of this beam a comparator was to be secured, and the comparisons were to be made upon the assumption that the beam did not change in length during the period of each comparison, or if change took place it might be measured by knowing the temperature of the beam and its coefficient of expansion.

As soon as the beam was constructed these daily comparisons were made. At northwest base this beam rested on the brick piers, but their comparators were in their places on the beam. At Camp Schott, at the close of the measurements, the beam also rested on brick piers; comparators on the beam.

The beam is described as follows, in Mr. Pratt's own words. Of course it would have been better made and with special adjustments if time and means had been available. It was made by Mr. Pratt in camp, and its working was satisfactory:

"The idea of using in the field a single beam so arranged that one base bar could be laid on it at a time and its measure or comparison taken, then removed entirely and replaced by another bar, and so on, was suggested to you, I believe, by Assistant Schott.

"The beam was proportioned and made to carry out Assistant Schott's suggestions, which accounts for its being so narrow. After it reached the field it was decided that it would be best to put all the bars on at one time, and I devised and executed all the present attachments. The crudeness of construction and arrangement was due to the limited means at hand. The planks that compose the beam are of thoroughly seasoned two-inch white cedar, and are securely bolted together in such a manner that they can be retightened at any time in case of shrinkage. In order to make it as portable as possible, the usual carriage for carrying the bars was discarded, the bars themselves acting for that purpose by simply resting on the two hard wood pieces, which are at right angles, and have round metallic rails fixed to their under sides. Each one of these rails rests on two grooved metallic rollers, one on either side of the beam; the two rollers on the back of the apparatus, as seen in the drawing (sketch No. 30), are connected with each other by a shaft, and also with the wheels at either end, which are used by the observers to move the bars backward and forward. There is a little lost motion in that portion of the shaft which is between the two metallic rollers, which enables the observers to give either end of the bars a slight independent movement.

"Under the points of support to each bar are placed diagonal metallic plates, with an adjusting screw in each end, by which means the bars are raised or depressed to the exact height of the abutting pieces on the comparators. By referring to the sketch the handles of these adjusting screws will be seen to project above the tops of the base bars."

MOVING THE BASE BARS INTO LINE.

Various plans were suggested to move the bar sideways by mechanical means, but that proposed by Mr. Gilbert was accepted as the simplest, and was capable of being made by a blacksmith. (See sketch No. 29.)

An iron rod one-half inch diameter and about 14 inches long had a coarse thread cut upon it for about four inches under the beam. One end of this rod was loosely fixed to the tripod just below the level of the under side of the bar beam and behind the uprights on the tripod. The free end of the screw bar, with a cross for turning by was lifted by the operator up and against the under side of the beam upon which was fastened an iron plate with a 3-inch longitudinal knife-edge placed at an angle with the bar equal to the thread of the screw. This knife edge therefore entered one of the threads, and as the screw was turned that end of the bar was necessarily moved sideways.

Had there been time and proper means for executing a fair piece of workmanship, it would have worked with sufficient smoothness; even as it was, we owe the quickness of our measures, in great part at least to this simple and coarsely made contrivance.

MEASURE FOR FRACTIONAL BARS.

It was almost certain that a fractional bar would need to be measured at the northwest end of the base-line, and also at each "fence stone."

To make such measures with accuracy I made known to Mr. Pratt what I wished done, and left the details to him. So I transcribe his description of the measure for the fractional bars as shown in sketch No. 30.

"The wooden portion of the bar is of thoroughly seasoned white cedar 0.05m thick, 0.113m deep, and 3.225m long; in order to prevent warpage it was split in two equal pieces and one of them turned 180°, and then they were securely fastened together. One of the lower edges was rabbeted out sufficiently to let in a steel bar 0.012m square; this steel bar was graduated to three metres, and each one of these individual metres was compared with a standard metre by means of a micrometer beam compass, which I devised especially for this purpose. Sliding on this steel rod is a vernier, with clamps and slow motion. On the side of the bar is an ordinary base-bar sector for measuring the inclination.

"In measuring a fraction of five metres, which occurred at all of the fence stones and at Northwest base, the zero of the bar was placed over, and usually in contact with, the fine point in the copper bolt, then the vernier was moved until it came vertically under, as determined by a transit sector, the end of one of the base bars; the whole metres were then read off subject to the corrections obtained by comparison, and the fractional portion of a metre was transferred, with a knife-edged beam compass, to a metre scale to be read."

ALIGNING TELESCOPES.

The aligning telescopes, one at the forward end of each bar, were upon my recommendation somewhat improved in their practical working, at the close of the first measurement, and subsequently Mr. Pratt fitted set screws to abut against a stud in the metallic end of the wooden beam, by which means they could be corrected in azimuth. Several improvements are yet desirable, and will be introduced.

In the second measurement the bars were aligned between adjacent kilometre stones.

COMPARATORS.

The observations for comparison of the base bars with the standard were made with the two micrometer Fauth lever of contact comparators which accompanied the apparatus. These comparators are described and illustrated in Assistant Schott's paper on the construction of the apparatus (Appendix No. 7).

[NOTE.—Assistant Davidson has studied carefully the working of the apparatus in the field, and has made plans for certain improvements suggested by the severe tests applied during the progress of the several measurements.]

RATE OF MEASUREMENT.

The following tabulation gives in detail the time occupied with each operation in the measurement in the field. It indicates how well the party increased in efficiency in the successive measurements. The summary very clearly exhibits the results attained.

	First measurement.	Second measurement.	Third partial measurement.
Total number of bars laid	3498	3498	1498
Total number of working days	20	18	8
Total number of working hours	183½	171¼	53¼
Average daily number of bars	175	194	187
Average daily number of bars per hour*	28	37	43
Highest hourly average for day	39	45	54
Highest number bars in one day	271	276	324
Highest number bars in one hour	42	49	57

*Actual time of laying the bars.

The actual time of working during the measurements, which amounted to 8 494 bars, was 408 hours. This included comparisons with the standard, adjustments, and all delays whatever from the time of reaching the field to leaving it. The average number of bars laid per hour under these conditions was $20\frac{3}{4}$. But the actual time of laying the 8 494 bars, not including any delays, was 247 hours; this gives an average of $34\frac{1}{3}$ bars per hour.

Tabulation of daily work.

FIRST MEASUREMENT. YOLO BASE LINE.

Date.	Time for comparisons.	Time for testing instruments.	Time for plumbing down.	Setting stones, accidents, etc.	Time for lunch, noon.	Sum of delays, etc.	Time of beginning work, a. m.	Time of ending work, p. m.	Time occupied during work.	Actual time of laying bars.	Number of bars laid during day.	Average number of minutes to each bar.	Average number of bars to each hour.
1881.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.			
September 19	0 15	0 35	0 56	0 15	0 50	2 41	8 20	5 40	9 20	6 39	126	3. 17	19
20	....	0 22	1 14	1 38	1 23	4 37	7 45	5 45	10 00	5 23	97	3. 33	18
21	....	0 16	0 30	....	0 45	1 31	7 55	5 25	9 30	7 59	163	2. 94	21
22	0 33	0 00	0 43	0 34	0 00	1 50	8 20	12 10	3 50	1 50	47	2. 34	26
24	0 17	0 00	0 83	1 29	1 00	4 09	7 50	5 52	10 02	5 53	115	3. 07	20
27	0 18	0 31	0 54	0 43	0 33	2 59	7 54	5 33	9 39	6 40	182	1. 87	27
28	0 40	0 20	0 44	1 08	1 00	3 52	8 32	5 38	9 06	5 14	134	2. 34	26
29	0 17	0 20	0 41	0 25	0 37	2 20	7 18	5 35	10 17	7 57	237	2. 01	30
30	0 19	0 15	0 32	1 54	0 41	3 41	7 12	5 20	10 08	6 27	185	2. 07	29
October 3	0 20	0 27	0 35	2 36	0 58	4 56	8 58	5 37	8 39	3 43	114	1. 96	31
4	0 22	0 16	0 40	0 57	1 09	3 24	7 12	5 20	10 08	6 44	225	1. 79	34
5	0 23	0 20	0 46	1 47	0 50	4 06	6 55	5 26	10 31	6 25	226	1. 70	35
6	1 11	0 19	0 52	0 54	0 57	4 13	7 23	5 20	9 57	5 44	192	1. 78	34
7	0 15	0 25	0 28	1 14	0 46	3 08	7 55	5 24	9 29	6 21	204	1. 86	32
8	0 38	0 16	0 31	0 46	0 59	3 10	7 28	5 23	9 55	6 45	229	1. 77	34
10	0 35	0 38	0 29	0 28	0 28	2 38	7 20	5 25	9 65	7 27	271	1. 65	36
11	0 36	0 23	0 28	0 54	0 43	3 04	7 36	4 49	9 13	6 09	201	1. 84	33
12	0 31	0 23	0 20	1 01	0 51	3 05	7 54	4 45	8 51	5 46	200	1. 73	35
13	0 35	0 10	0 38	0 23	0 50	2 36	8 20	4 50	8 30	5 54	231	1. 53	39
14	0 35	0 13	0 06	1 33	....	2 27	7 55	2 18	6 23	3 56	119	1. 99	30
Average=	....	....	....	....	....	....	....	....	....	....	175	2. 14	28

Number of days, 20; total number of bars, 3 498; actual time of laying bars, 118 hours 56 minutes.

SECOND MEASUREMENT. YOLO BASE LINE.

October 17	0 31	1 22	0 44	0 43	0 48	4 08	8 15	5 07	8 52	4 44	106	2. 68	22
18	0 35	1 09	0 40	....	0 34	2 58	8 45	4 39	7 54	4 56	168	1. 76	34
19	0 44	1 12	0 39	0 41	0 48	4 04	7 50	4 43	8 53	4 49	160	1. 81	33
20	0 45	0 41	0 36	0 15	0 45	3 02	7 50	4 50	9 00	5 58	220	1. 63	37
21	0 31	0 13	0 47	0 31	0 45	3 47	8 00	4 53	8 53	5 06	192	1. 59	38
22	0 30	0 38	0 26	0 38	0 45	2 57	7 45	4 24	8 39	5 42	252	1. 32	45
24	0 37	0 53	0 41	0 15	0 36	3 02	7 08	4 37	9 29	6 27	256	1. 51	40
25	0 37	0 28	0 41	0 53	1 11	3 50	7 17	4 25	9 08	5 18	192	1. 66	36
26	0 36	0 40	0 36	0 14	0 20	2 26	7 00	1 35	6 35	4 09	166	1. 50	40
27	0 49	0 39	0 22	....	....	1 50	12 40	4 43	4 03	2 13	94	1. 42	42
28	0 30	0 41	0 22	0 09	0 42	2 24	7 50	4 45	8 55	6 31	200	1. 85	33
29	0 37	1 02	0 18	1 58	1 10	5 05	7 00	4 48	9 48	4 43	174	1. 63	37
31	0 31	0 51	0 26	0 56	0 39	3 23	7 00	4 55	9 55	6 32	242	1. 62	37
November 2	0 35	0 50	0 51	0 15	0 44	3 15	7 10	4 50	9 40	6 25	250	1. 54	39
3	0 38	0 47	0 41	0 43	0 55	3 44	7 20	4 55	9 35	5 51	252	1. 39	43
4	0 49	0 31	0 36	0 45	0 47	3 28	7 30	4 45	9 15	5 47	230	1. 51	40
5	0 35	0 33	0 24	0 33	0 45	2 50	7 40	4 50	9 10	6 20	276	1. 38	43
7	0 30	0 30	0 23	....	....	1 23	7 50	11 11	3 21	1 58	68	1. 74	34
Average =	....	....	....	....	....	....	....	....	....	....	194	1. 64	37

Number of days, 18; number of bars, 3 498; working hours, $171\frac{1}{2}$; total actual time of laying bars, 93 hours 29 minutes.

THIRD PARTIAL MEASUREMENT. YOLO BASE LINE.

Date.	Time for comparisons.	Time for testing instruments.	Time for plumbing down.	Setting stones, accidents, etc.	Time for lunch, noon.	Sum of delays, etc.	Time of beginning work, a. m.	Time of ending work, p. m.	Time occupied during work.	Actual time of laying bars.	Number of bars laid during day.	Average number of minutes to each bar.	Average number of bars to each hour.
November 11	0 35	0 57	0 27	0 44	0 32	3 15	7 30	4 30	9 00	5 45	242	1.43	42
12	0 31	0 22	0 19	0 24	....	1 36	7 27	12 50	5 23	3 47	158	1.44	42
14	0 39	0 27	0 38	0 10	0 22	2 16	7 52	4 20	8 28	6 12	252	1.48	41
16	0 37	0 26	0 20	0 13	....	1 36	9 10	2 10	3 00	1 24	46	1.83	33
18	0 25	1 26	0 49	0 15	0 22	3 17	8 45	4 35	7 50	4 33	178	1.53	39
19	0 55	0 30	0 31	0 22	0 31	2 49	8 08	4 13	8 05	5 16	222	1.43	42
21	0 34	0 46	0 46	0 10	0 25	2 41	7 45	4 28	8 43	6 02	324	1.12	54
22	0 32	0 18	0 13	0 11	....	1 14	8 00	10 46	2 46	1 32	76	1.21	50
Average...	....	....	....	....	....	....	....	....	....	....	187	1.40	43

Number of days, 8; number of bars, 1 498; working hours, $53\frac{1}{4}$; total actual time of laying bars, 34 hours 31 minutes.

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APPENDIX No. 9.

FIELD-WORK OF THE TRIANGULATION.

By RICHARD D. CUTTS, Assistant.

[Reprinted, with additions, from the Coast Survey Report of 1868.]

Geodesy, in practice, may be described as a system of the most exact land-measurements, extended, in the form of a triangulation, over a large area; controlled, in its relation to the meridian, by astronomical azimuths; computed by formulæ based on the dimensions of the spheroid; and placed in its true position on the surface of the earth by astronomical latitudes and differences of longitude from an established meridian.

In inverse order the same system of operations, when conducted in the general direction of the meridian or of the parallel, determines the length, in standard measures, of the astronomical degrees comprised within the measured arc, and hence redetermines a value for the dimensions and figure of the earth.

Three orders of triangulation are recognized in the geodetic operations carried on for the survey of the coast:

I. The primary series, with sides varying in length from about 20 to 100 miles or more, such as those which are completed or in progress from the river Saint Croix to Cape Henry; between the Kent Island and Atlanta bases; on the line of the geodetic connection between the Atlantic and Pacific coasts; and from Oregon to San Diego.

II. The second series, with sides from about 5 to 40 miles in length, either connecting the tertiary with the primary, or which, starting from independent bases, is being gradually extended over the coasts, sounds, and bays from the mouth of the Chesapeake to the Rio Grande; and, on the Pacific, from British Columbia to the southern boundary of California.

III. The tertiary triangulation, with sides less than about 6 miles in length, which follows the immediate line of the coast for the use of the topographical and sounding parties, and includes the short series which branch off from the secondary and are carried up the smaller rivers and inlets of the sea.

The primary and part of the secondary series, composed principally of quadrilaterals, and verified, at intervals, by the measurement of additional bases and new determinations of the astronomical azimuth, latitude and longitude, constitute the standard geodesy of the survey. From this special class of the geodetic work, subject to the least probable error, the dimensions and figure of the earth are deduced, as in the measurements, made and in progress, of the arcs of the meridian in the Eastern, Middle, and Southern States, and of the arc of the thirty-ninth parallel across the continent.

RECONNAISSANCE.

A system of simple triangles entails the least labor; one of hexagons covers the largest area; while a series of quadrilaterals secures the greatest degree of accuracy. The last system is the rule in the survey, although the other two are occasionally employed according to the necessities of the case or to the particular object to be accomplished.*

A careful reconnaissance invariably precedes the selection of new points for the continuation of the geodetic work of the survey. The first step will be to decide upon the proportions of the

* See Appendix 20, Report of 1879.

scheme best adapted to the character of the country and for the success and progress of the work, and the next the reconnaissance in detail. In the case of high elevations and an open country, little difficulty will be encountered; but if the hills are densely wooded and tolerably uniform in height, the greatest care and skill are needed to select such intervisible points as are the most favorably situated, not merely for the extension of the triangulation, but to satisfy other conditions imposed by the survey. Should the land be uniformly low and clear, the triangulation may be laid off, as on paper, restricted only in its proportions by the curvature of the earth and the height to which the signal and instrument should be elevated; but if covered with forest or heavily-timbered swamp, the length of the lines will be governed by the labor and expense of opening them, taking into view the possibility of carrying on a smaller series of triangles immediately on the coast, or of a direct measurement of the beach, to be continued until such difficult section has been passed.

If the reconnaissance covers any extended portion of the coast, and a scheme be adopted for the geodetic work, the question will arise whether the proposed triangulation, from its proportions, as determined by the character of the country, will need verification before joining on with the principal bases as measured in each section; and if so, at what intermediate points could such subsidiary lines and azimuths be measured and observed for the correction of the distances and directions.

In the performance of the above duty, the assistant will keep steadily in view the requirements alike of the triangulation and of the survey; and it will be his aim so to modify and adjust them, each in the ratio of its value, to the special features of the country under examination, as to produce a plan of triangulation which, while it satisfies the conditions prescribed, will be the most effective in its results and economical in its execution. The most important of these requirements, beyond the paramount condition of the certain intervisibility of the stations intended to be connected, are—

I. The adoption of the highest elevations.

II. The maximum length of line consistent with the limit of 30° prescribed for the least size or an angle. A smaller angle is admissible in quadrilaterals, and also at one end of a base of known line, but not at any new point to be determined.

III. The forming of quadrilaterals whenever possible.

IV. The modifications or changes which can be effected in the position of the proposed stations, so as to avoid, as much as possible, the labor and expense of opening lines through the forest or swamp.

V. The sweep of the horizon, or of the area to be surveyed, with a view to the easy determination of intermediate stations, and of light-houses, spires, chimneys, or other prominent objects not more than two or three miles apart, for the special use of the plane-table and hydrographical parties.

VI. The capacity of the station ground to be protected from the destructive effects of storms and waves and from the ordinary pursuits of man, with a view to the preservation of the station for future use.

VII. The consideration of the altitude to which the theodolite must be raised to escape the variable refraction incident to the visual ray passing close to the surface of the ground.

In case a base of verification is required within the area covered by the reconnaissance, the examination will be more in detail. For the primary work, its length should be not less than 6 miles, and for the secondary between 2 and 3 miles. The site selected should be a level piece of land, the slope of the ground not to exceed four degrees; it should be as free as possible of accidents, such as rivulets, ravines, or irregularities in the surface, in order that the preparation of the line may not be too expensive; and its termini should be in such positions that they can be connected by well-shaped quadrilaterals, either directly or through a short series, with the main triangulation in its vicinity.

The reconnaissance requires the following outfit: A telescope and tripod, the latter with a small circle read by a vernier to 20 minutes; a declination-needle, to be clamped, at will, on the telescope, so that the zero-mark and the visual axis of the telescope will be in the same line; and, if in a hilly or mountainous country, a pocket aneroid barometer and detached thermometer. The index and scale errors, if any, of the aneroid should be determined and entered in the record. If of small value they can be overlooked, as differences and not absolute heights are measured.

The following formula will give the difference in height between two stations at which the aneroid and thermometer have been read within a few hours' interval of time. The shorter the interval, the better.

Difference.......... .... $=60345$ feet (log B$-$log b)

Mean temperature... .... $=\dfrac{T+t}{2}$

The factor varies with the mean temperature. For every degree above 32° F., add 134 to 60345

Example.

$B=28.72$	$\log B=1.4581844$		
$b=27.14$	$\log b=1.4336098$		log's.
		0.0245746	8.3904865
$\dfrac{T+t}{2}=62^\circ.5$, and, hence,		64432	4.8091016
		Difference=1583.4 feet	3.1995881

Or the difference in height may be taken out from the following table, by interpolation of tenths, as follows:

28.72 at 62°.5 for 1220.0 feet
27.14 at 62°.5 for 2803.6 feet

Difference.. 1583.6 feet

Difference in height, in feet, between two stations, at the mean of the two observed temperatures.

Barometer.	Mean of observed temperatures in degrees Fahrenheit.						
	32°.	42°.	52°.	62°.	72°.	82°.	92°.
30.0	....	....	....	....	....	....	....
29.9	87.5	89.4	91.4	93.3	95.3	97.2	99.2
29.8	175.3	179.2	183.1	187.0	190.9	194.8	198.7
29.7	263.4	269.3	275.1	280.9	286.8	292.7	298.5
29.6	351.8	359.6	367.4	375.2	383.0	390.9	398.7
29.5	440.5	450.3	460.0	469.8	479.6	489.4	499.2
29.4	529.5	541.3	553.0	564.7	576.5	588.2	600.1
29.3	618.8	632.6	646.3	659.9	673.7	687.4	701.3
29.2	708.4	724.2	739.9	755.4	771.3	787.0	802.8
29.1	798.3	816.1	833.8	851.3	869.2	886.9	904.7
29.0	888.5	908.2	927.9	947.6	967.4	987.2	1007.0
28.9	979.0	1000.7	1022.4	1044.2	1065.9	1087.8	1109.6
28.8	1069.9	1093.5	1117.3	1141.1	1164.8	1188.8	1212.6
28.7	1161.1	1186.7	1212.5	1238.3	1264.1	1290.0	1315.9
28.6	1252.5	1280.3	1308.1	1335.9	1363.8	1391.6	1419.5
28.5	1344.3	1374.2	1404.0	1433.8	1463.7	1493.6	1523.5
28.4	1436.4	1468.4	1500.2	1532.1	1563.9	1595.9	1627.9
28.3	1528.5	1562.9	1596.8	1630.7	1664.5	1698.6	1732.7
28.2	1621.5	1657.7	1693.7	1729.6	1765.6	1801.7	1837.9
28.1	1714.6	1752.8	1790.9	1828.9	1867.0	1905.2	1943.4
28.0	1808.1	1848.3	1888.5	1928.6	1968.8	2009.0	2049.3
27.9	1901.9	1944.2	1986.4	2028.6	2071.0	2113.2	2155.6
27.8	1996.0	2040.4	2084.7	2128.9	2173.5	2217.8	2262.3
27.7	2090.5	2136.9	2183.4	2229.6	2276.3	2322.7	2369.3
27.6	2185.2	2233.8	2282.4	2330.7	2379.4	2428.0	2476.7
27.5	2280.3	2331.1	2381.7	2432.2	2482.9	2533.6	2584.5
27.4	2375.8	2428.7	2481.4	2534.1	2586.8	2639.6	2692.7
27.3	2471.6	2526.7	2581.3	2636.2	2691.1	2746.0	2801.3
27.2	2567.8	2625.0	2681.9	2738.9	2795.9	2852.9	2910.3
27.1	2664.3	2723.6	2782.6	2841.8	2901.0	2960.2	3019.7
27.0	2761.2	2822.6	2883.9	2945.1	3006.5	3067.9	3129.5

The following table will be of use in the reconnaissance, and in arranging the height of the signal and observed tripod to be erected for long lines over water or level land. The line of sight from the telescope to the signal should never be allowed to pass less than 6 feet above the ground at the tangent point.

Difference in feet between the apparent and true level at distances varying from 1 *to* 66 *miles.*

Distance, miles.	Difference in feet for—			Distance, miles.	Difference in feet for—			Distance, miles.	Difference in feet for—		
	Curvature.	Refraction.	Curvature and refraction.		Curvature.	Refraction.	Curvature and refraction.		Curvature.	Refraction.	Curvature and refraction.
1	0.7	0.1	0.6	23	353.0	49.4	303.6	45	1351.2	189.2	1162.0
2	2.7	0.4	2.3	24	384.3	53.8	330.5	46	1411.9	197.7	1214.2
3	6.0	0.8	5.2	25	417.0	58.4	358.6	47	1474.0	206.3	1267.7
4	10.7	1.5	9.2	26	451.1	63.1	388.0	48	1537.3	215.2	1322.1
5	16.7	2.3	14.4	27	486.4	68.1	418.3	49	1602.0	224.3	1377.7
6	24.0	3.4	20.6	28	523.1	73.2	449.9	50	1668.1	233.5	1434.6
7	32.7	4.6	28.1	29	561.2	78.6	482.6	51	1735.5	243.0	1492.5
8	42.7	6.0	36.7	30	600.5	84.1	516.4	52	1804.2	252.6	1551.6
9	54.0	7.6	46.4	31	641.2	89.8	551.4	53	1874.3	262.4	1611.9
10	66.7	9.3	57.4	32	683.3	95.7	587.6	54	1945.7	272.4	1673.3
11	80.7	11.3	69.4	33	726.6	101.7	624.9	55	2018.4	282.6	1735.8
12	96.1	13.4	82.7	34	771.3	108.0	663.3	56	2092.5	292.9	1799.6
13	112.8	15.8	97.0	35	817.4	114.4	703.0	57	2167.9	303.5	1864.4
14	130.8	18.3	112.5	36	864.8	121.1	743.7	58	2244.6	314.2	1930.4
15	150.1	21.0	129.1	37	913.5	127.9	785.6	59	2322.7	325.2	1997.5
16	170.8	23.9	146.9	38	963.5	134.9	828.6	60	2402.1	336.3	2065.8
17	192.8	27.0	165.8	39	1014.9	142.1	872.8	61	2482.8	347.6	2135.2
18	216.2	30.3	185.9	40	1067.6	149.5	918.1	62	2564.9	359.1	2205.8
19	240.9	33.7	207.2	41	1121.7	157.0	964.7	63	2648.3	370.8	2277.5
20	266.9	37.4	229.5	42	1177.0	164.8	1012.2	64	2733.0	382.6	2350.4
21	94.3	41.2	253.1	43	1233.7	172.7	1061.0	65	2819.1	394.7	2424.4
22	322.9	45.2	277.7	44	1291.8	180.8	1111.0	66	2906.5	406.9	2499.6

$$\text{Curvature} = \frac{\text{square of distance}}{\text{mean diameter of earth}}$$

$$\log \text{curvature} = \log \text{square of distance in feet} - 7.6209807.$$

Refraction $= \frac{K^2}{R} m$, where K represents the distance in feet, R the mean radius of the earth ($\log R = 7.3199507$), and m the coefficient of refraction, assumed at .070, its mean value, sea-coast and interior.

$$\text{Curvature and refraction} = (1 - 2m) \frac{K^2}{2R}.$$

Or, calling h the height in feet, and K the distance in statute miles, at which a line from the height h touches the horizon, taking into account terrestrial refraction, assumed to be of the same value as in the above table (.070), we have—

$$K = \frac{\sqrt{h}}{.7575} \qquad h = \frac{K^2}{1.7426}.$$

The following examples will serve to illustrate the use of the preceding table:

I.—*Elevation of instrument required to overcome curvature and refraction.*

Let us suppose that a line, A to B, was 18 miles in length over a plain, and that the instrument could be elevated at either station, by means of a portable tripod, to a height of 20 or 30 or 50 feet. If we determine upon 36.7 feet at A, the tangent would strike the curve at the distance represented by that height in the table, viz, 8 miles, leaving the curvature (decreased by the ordinary refraction) of 10 miles to be overcome. Opposite to 10 miles we find 57.4 feet, and a signal at that height erected at B would, under favorable refraction, be just visible from the top of the tripod at A, or be on the same apparent level. If we now add 8 feet to tripod and 8 feet to signal-pole, the visual ray would certainly pass 6 feet above the tangent point, and 20 feet of the pole would be visible from A.

II.—*Elevations required at given distances.*

If it is desired to ascertain whether two points in the reconnaissance, estimated to be 44 miles apart, would be visible one from the other, the natural elevations must be at least 278 feet above mean tide, or one 230 feet, and the other 331 feet, &c. This supposes that the intervening country is low, and that the ground at the tangent point is not above the mean surface of the sphere. If the height of the ground at this point should be 200 feet above mean tide, then the natural elevations should be 478, or 430 and 531 feet, &c., in height, and the line is barely possible. To insure success, the theodolite must be elevated, and at both stations, to avoid high signals.

III.—*To determine whether the line of sight between two stations would pass above or below the summit of an intervening hill, and how much in either case.*

h_1 = height of lower station. d_1 = distance h_1 to h_2.
h_3 = height of higher station. d_2 = distance h_2 to h_3.
h_2 = height of intervening hill.

Example I.

$h_1 = 600$ feet.	600 feet strikes horizon at	32.3 miles,
$h_3 = 2000$ feet.	$64 - 32.3 = 31.7$ miles	577 feet of elevation,
$h_2 = 1340$ feet.	$31.7 - 10 = 21.7$ miles	270 feet of elevation,
$d_1 = 54$ miles.	$2000 - 577$ feet	$= 1423$ feet,
$d_2 = 10$ miles.	$\frac{64}{10} = 6.4$ and $\frac{1423}{6.4}$	$= 222.3$ feet,

and h or height of line at $h_2 = 1423 + 270 - 222.3 = 1470.07$ feet.

Hence, the line passes 130.7 feet above the intervening hill and the stations are intervisible.

Example II.

$h_1 = 900$ feet.	900 feet strikes horizon at	39.4 miles,
$h_3 = 3600$ feet.	80 miles $-$ 39.4 miles $= 40.6$ miles	946.0 feet of elevation,
$h_2 = 1980$ feet.	$40.6 - 25.0 = 15.6$ miles	139.8 feet of elevation,
$d_1 = 55$ miles.	3600 feet $-$ 946 feet	$= 2654.0$ feet,
$d_2 = 25$ miles.	$\frac{80}{25} = 3.2$ and $\frac{2654}{3.2}$	$= 829.4$ feet,

and $h = 2654 + 139.8 - 829.4 = 1964.4$ feet.

Hence, the summit at h_2 is 15.6 feet higher than the line of sight, and the two stations are not intervisible.

If we elevate the instrument 60 feet at h_3, the line would pass clear of h_2, or its height at that point would be 2,006 feet.

The question of intervisibility may be also determined by the following formula, in which the coefficient of refraction is reduced to .065.

$$h = h_1 + (h_3 - h_1)\frac{d_1}{d_1 + d_2} - 0.5803\ d_1\ d_2$$

Example III.

For which we employ the same data as in Example I.

					log's.
$(h_3 - h_1) =$	1400 feet	$\log (h_3 - h_1)$	$= 3.14613$	$d_1 = 54$ miles	1.73239
$d_1 =$	54 miles	$\log d_1$	$= 1.73239$	$d_2 = 10$ miles	1.00000
$d_1 + d_2 =$	64 miles	Co. $\log (d_1 + d_2)$	$= 8.19382$	Constant	9.76365
	1181.2 feet		3.07234	313.4 feet	2.49604

and, hence, $h = 600$ feet $+ 1181.2 - 313.4 = 1467.8$ feet.

NAMES OF STATIONS.

The station should be called after the popular designation of the hill or site on which it is situated; or after some peculiarity in the ground or formation well known in the neighborhood; or from the name of the owner or tenant of the land; or where neither owner nor distinctive traits are to be found, by such designation as, in the opinion of the assistant, will best serve to attract attention to the special locality. The same name should not occur twice within the same section of country. If it should be necessary to re-occupy the station, and the center cannot be positively identified, the fact should be stated, and the approximate position be designated as No. 2, or by the year of the re-occupation, as, for instance, Red Hill^2 or Red Hill^{1869}. If the new position is merely in the vicinity of the old station, an entirely new name should be given to it.

SIGNALS.

The following signals are employed in the triangulation, according to circumstances:

I. The heliotrope carefully adjusted, on a stand or tripod, to the center of station, and the pointing watched and attended to by an employé trained for the duty. This signal is used when long lines are to be observed, or those rendered difficult by haze, smoke, or other impurities in the atmosphere.

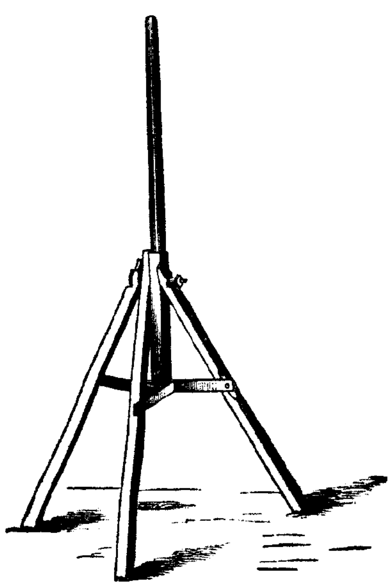
II. A reflector, such as the frustum of a tin cone, mounted on a stout pole, supported and retained in position by a tripod, and by wire guys, is advisable.

III. And in short lines, the simple pole supported by a tripod.

IV. Night signal, such as the ordinary coal-oil lamp with a reflector, or, for long lines, ribbons of magnesium burned and regulated by special apparatus.

The height of the pole and dimensions of the tripod; the boarding of the upper and lower part, or the color of the pole, whether black or white, or with alternate bands of each, to insure prompt recognition; and the character of the mark, if any, centered on the top, to be used for identification, will vary with and depend upon the length of the line, the altitude of the station, the background of the signal as seen from the points of observation, and the atmospheric difficulties to be overcome.

In regard to the diameter of the pole to be observed upon, it is evident that, in short lines, it should not exceed the size just sufficient to admit of its being distinctly seen, as all beyond that is a source of error, arising from the additional range given to the bisecting thread.



The diameter which subtends an angle of one second at one mile is 0.307 of an inch, and hence, at

20 miles it is 6.1 inches. 60 miles it is 18.4 inches.
40 miles it is 12.3 inches. 80 miles it is 24.6 inches.

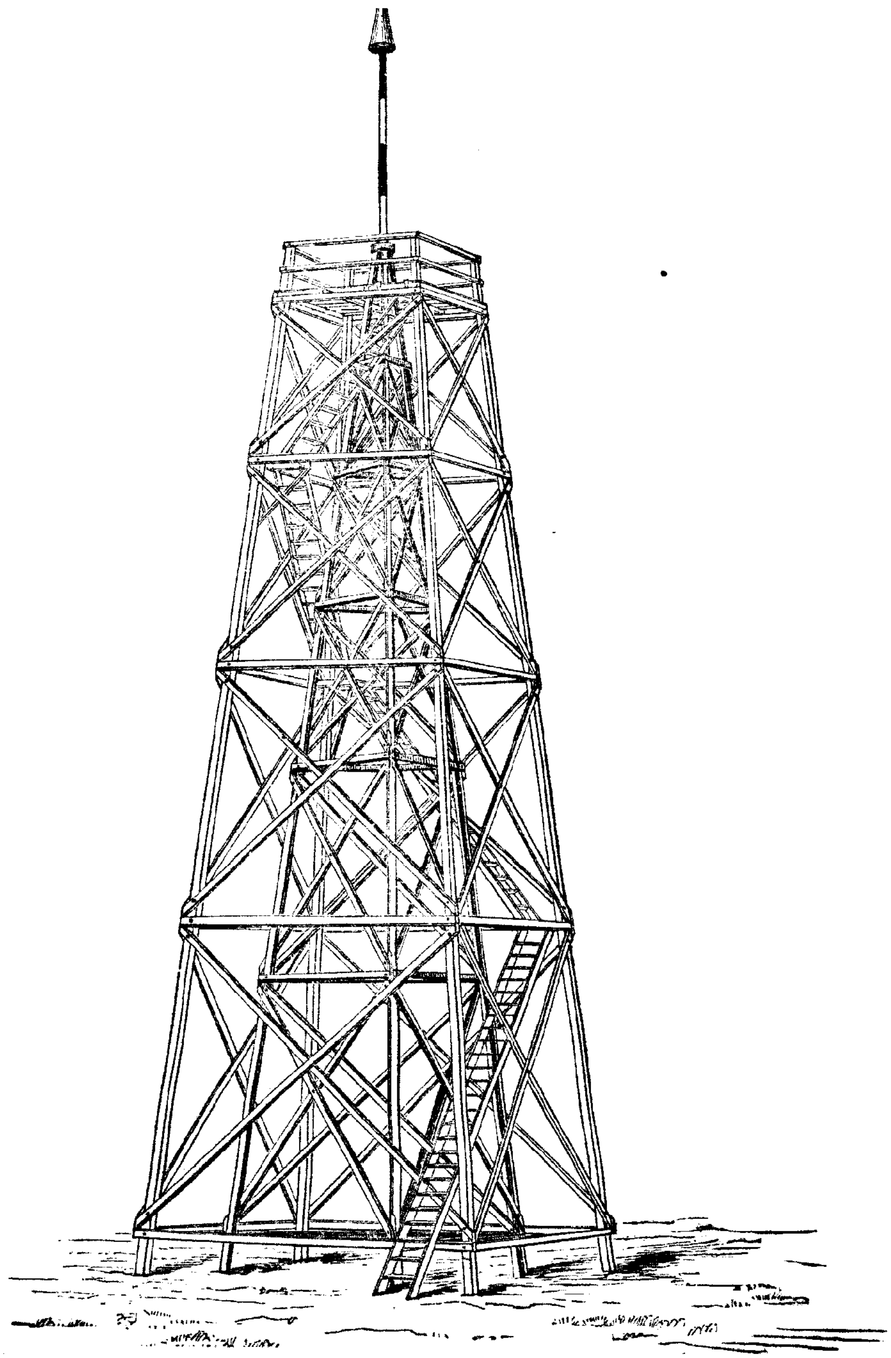
These proportions show that, for lines exceeding 15 miles in length, the diameter of the signal should not exceed one second in value; while, on the other hand, as the pole, when distinct, should be observed upon in preference to the heliotrope, and can be best seen during cloudy periods, it would be advisable, in long lines, to give to the pole nearly its full size; and it may be added that the height in signal adds to its visibility and distinctness.

A sketch of a tripod-signal is presented, the height of which varies from 15 to 65 feet. The solid part of the pole above the apex of the tripod should not exceed 8 or 10 inches in diameter, otherwise it would be too heavy to raise. When once in position, the upper part can be increased to the desired diameter by nailing on slats of light seasoned wood, or this addition may be partially made before raising.

In the erection or use of any kind of signal no chance for an error in the determination of the angle should be allowed by a want of care and precision in centering the mark to be observed upon exactly over the center of the station. And should this source of error be at any time suspected, an examination should be promptly made, and if found to exist, the distance and direction of the point, or center of the object actually observed upon from the center of the true station, should be measured and recorded for the correction of the angles. (See formula for eccentricity of signal.)

In no case should the foot of the pole be inserted in or be allowed to come in contact with the earthenware cone or other article buried as an underground mark. Six or eight inches of earth, carefully packed above the cone or block, and upon this a square foot or so of board, upon which the pole can rest, will be sufficient to afford a foothold when such is necessary, and, at the same time, to prevent any displacement of or injury to the mark in case the pole should be roughly handled or blown down.

OBSERVING TRIPODS AND SCAFFOLDS.



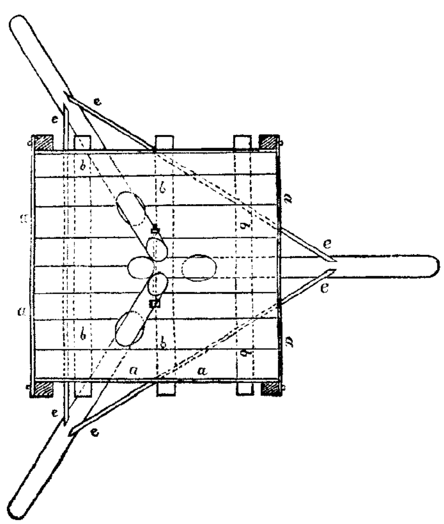
The tripod and scaffold, which are frequently erected for the elevation of the instrument and observer, in order to obtain a longer length of line or to escape the troubled condition of the atmosphere usually lying immediately over the low flat lands bordering the coasts and shores, vary in height from 10 to 60 feet, and are made of scantling purchased for the purpose, or of materials obtained from the forest, and are built in general accordance with the plans and specifications given in the annual reports. While a strict adherence to uniformity in the details of the construction is not possible, so much depending upon the means and facilities at the disposal of the assistant, and upon a proper regard to economy, the general principles of strength and solidity, in both tripod and scaffold, are strictly observed by a proper spread and anchoring of the feet, a thorough bracing of the legs, and a compact fitting of the cap to the top of the tripod. A careful attention to these points will secure perfect immobility while the observations are being made and sufficient firmness to keep the scaffold entirely and always free from contact with the tripod, and to enable both structures to resist the most violent storms.

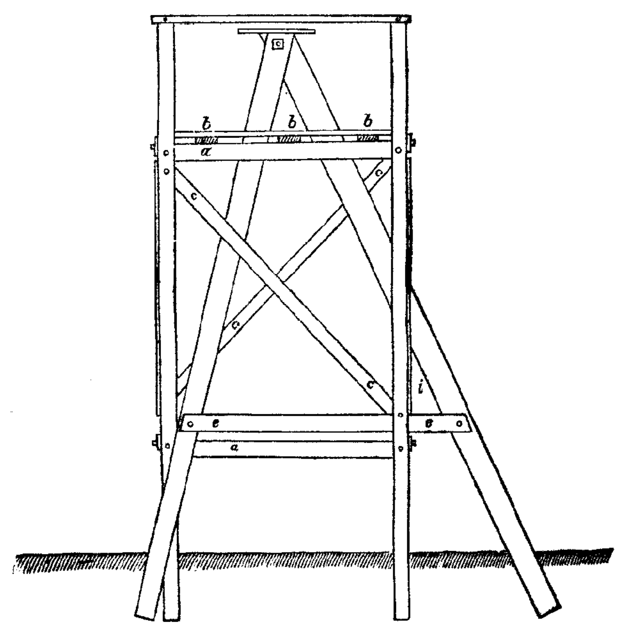
A drawing of such a tripod and scaffold is here given. It will be noticed that the diagona braces of the tripod are spiked to the legs, one on the outside and the other on the inside, and that a space is left between the two braces where they cross. By drawing together these diagonals on each face of the tripod, the structure can be screwed up or stiffened, in case it becomes loose from shrinkage or other cause.

The following description and plan of a small portable tripod and scaffold may be of service, the height being well adapted for short lines on the southern coast:

Tripod.—This is made of three legs, 18 feet long and 6 inches in diameter, bolted together, 3 inches from the top, with an inch bolt, 16 inches long. After they are fitted together at the head the spread being 13 feet, and before raising, one of the braces, *e e*, is screwed to the two outside legs, so as to keep them in place while raising the tripod by the third leg. It is then settled 2 feet in the ground, care being taken to level it by the braces *e e*, which are to be screwed on with wooden screws.

Scaffold.—Four posts, $16\frac{1}{2}$ feet long and 5 inches square; 8 cross-pieces, 7 feet long and 6 inches by $1\frac{1}{4}$, *a a;* 3 cross-pieces, 7 feet long and 6 inches by 1, *b b;* 4 braces, 10 feet long and 5 inches by $1\frac{1}{4}$, *c c;* 8 flooring pieces, 7 feet 3 inches long and $9\frac{1}{4}$ by 1, with holes for the tripod-legs.





The end posts are those on which the braces and cross-pieces screw on the outside, and which are to be fastened together in pairs, when on the ground, so that it may be raised after the manner of a bedstead or house frame. The braces *c c* are to be bolted to the upper ends to steady the posts when raising them. All the holes in the posts, cross-pieces, and braces are to be identical as to plan and size, as also the pieces themselves, so as to have no mistakes, and when raised the scaffold fits to the tripod, as shown in the drawing. The scaffold is leveled by the cross-pieces and adjusted, and in firm position after the floor is on, so as to be free from the tripod. The floor is to be 2 feet 10 inches below the top of the tripod. Three iron knees are screwed to the tripod-legs near the top, so that the triangular piece for the theodolite can be bolted to them. This piece is made of two pieces of one-inch plank, screwed together across the grain, and then painted. Holes are made in the floor for the tent-posts, and wire guys are sometimes required for the scaffold.

The above takes about two hours to put up. One large and two small wrenches are necessary; also a bag to contain the screws, nuts, &c. Should more than one be needed, they should be painted different colors, but be, in all other respects, exactly alike, in order that one can be used to repair the other.

THE UNDERGROUND STATION-MARKS.

The station-marks include the underground and surface marks; the former to be buried, and the latter to be thrown up for the preservation of the center and of the position of the station.

The requisites for an underground mark or one buried below the frost and plow line, and beyond the reach of ordinary accident or interference, say three feet, in the clear, below the surface, are: indestructibility, peculiarity, capacity to resist displacement in case it should be accidentally struck, cheapness, and, finally, want of value for any of the ordinary purposes of life, as a protection against cupidity. The following marks, partaking more or less of these essential qualities, have been adopted in the survey:

1. The frustum of a hollow stoneware cone, called the Hassler cone. The dimensions for primary stations are for the upper and lower diameters and the height 8, 12, and 15 inches, respectively.

2. One similar in shape to the preceding, but made of iron, and occasionally with a rim like that of a hat, encircling the larger diameter, upon which are inscribed in the casting the words "U. S. C. and G. Survey," or an abbreviation thereof.

3. A hollow stoneware pyramid.

4. A short column of marble, granite, or sandstone, manufactured for the purpose, and in some cases placed above the cone, the top reaching within six inches of the surface.

5. A block composed of brick or stones and hydraulic cement.

6. A bottle with three others just below the surface pointing to the lower one.

The center of the station in the cone is either the center of the periphery or the intersection of two lines drawn on the head of a copper tack driven in a stub placed and packed inside of cone, and sometimes extending within a foot of the surface; or, when a block is used, by the intersection of cross-lines on the head of a copper bolt inserted for the purpose. The initials U. S. C. & G. S. are occasionally cut upon the block.

Of these and other varieties of underground marks which have been adopted at times from choice and again from necessity, the stoneware or iron cones are clearly to be preferred.

THE SURFACE STATION-MARKS.

The surface marks are so varied in their character, and depend so much upon the nature of the ground, that no special rules can be established for their selection. What would be highly appropriate in one case would be equally inappropriate in another; and at many localities, such as those affected by the winds and waves, and unavoidable as stations from the necessities of the work, no marks whatever can be arranged or erected with any hope of permanency, except at considerable expense. As the object of the surface marks is to secure the position and recognition of the station at any time hereafter, it is evident that the general principles which should govern in each case, to the full extent to which the locality will admit of their application, are, permanency or durability, facility with which they can be recognized, and the absence of value for any domestic or farm purpose. The following methods of marking have been employed in the survey:

1. A hole an inch or two in diameter, drilled in the rock on which the signal stands, and filled with lead, sulphur, or a copper bolt.

2. In the case of earth, a stone block, pillar, or post, marking the center of the station, and three others, two in line and one at right angles, equidistant from the center.

3. A large rock rolled to center and there sunk, or a block constructed of brick or stones and hydraulic cement, with the usual drilled hole and bolt of lead, copper, or sulphur.

4. An iron screw-pile, the center being marked on the cap, and also on a stub inside of tube, the top of stub having been previously covered with a disc of copper sheeting, on which the initials of the survey and date are punctured.

5. Owing to the requirements of the survey, many of the stations are located on the immediate line of coast, or on the margin of the low shores of the Gulf and Southern sounds. When situated on a sand knoll or hill, the point is secured by a screw-pile, or a stone block packed in a box or framework of wood; and by the introduction, at and around the station point, of clay or marsh mud, or other foreign substance convenient to the locality, and the knoll protected from the moving effect of the wind by abattis, constructed of a circle or circles of stakes interwined with brushwood, an accumulation of sand being less objectionable than the denuding of the station-marks.

6. Or, in case of a raised beach, subject to being washed away during a heavy gale, or by the slower action of the currents, beside the usual station-marks, a point of reference is established back from the shore-line, and its relation to the center of the station, determined by a careful measurement of the distance and azimuth between the two, so that the duplicate point may be used, or another established as an eccentric station, should such be needed at any time hereafter.

7. When the station is situated on the margin of a marsh, or a wooded swamp, it is secured by a screw-pile, or long pieces of scantling forced as far possible into the yielding soil, and projecting two or three feet above the surface.

8. Beside the natural elevations occupied as stations, those of an artificial character have been made available whenever it was expedient to do so, such as light-houses, towers, steeples, houses, barns, &c. The center of the station, when it can be marked, is designated, in the case of stone or cement, by the usual drilled hole and bolt; or, where metal is found, by a point within a triangle, both deeply engraved; or, in the case of wood, by a wooden pin driven in an auger-hole bored within a triangle cut, or formed by copper tacks, or by a piece of copper sheeting nailed to the wood and marked as above.

9. In addition to one or the other of the above marks, to be selected according to its special applicability to the case, the position is secured, whenever possible, by a circular trench, either left open or filled with charcoal or other substance foreign to the position, and then covered up, or by a mound of earth or pyramid of stones covering the surface-marks.

10. By points of reference, such as measurements and magnetic courses, from the center of the station to rocks in situ, stone walls, houses, trees, stakes in the prolongation of the lines to other stations, or to some prominent hill or building, and to other more or less permanent objects, artificial or natural. When the points referred to are within measuring distance, they should be designated by a triangle or other appropriate mark.

11. By a written description and topographical plan of the ground, its surroundings, and approaches, including the station-marks, the points of reference, and the courses and distances thereto. The name of the owner or tenant of the land, and of the resident or neighbor who has been requested to take charge of the station, or of others who will know most about its position, should be given.

12. And, finally, at important stations, by views and sketches of the locality and its peculiarities, from different points, as a further means of identification.

The stone pillars or posts are from 4 to 6 inches square, and vary in length from 24 to 30 inches; the blocks or monuments from 8 to 24 inches square, and from 18 to 20 in depth, and in all cases sunk nearly level with the ground. The usual cross-lines to define the actual center are drawn on these as well as on the bolts, and the letters U. S. C. & G. S. in some cases cut upon the stone.

The distance of the three surface-marks, whether of stone or cedar, as referred to in No. 2, should be uniformly 6 feet from the center of station, unless a different distance is unavoidable from the nature of the ground. Each should have an arrow-head on it, pointing to the center of the station, and they should be placed north, south, and east, in order to facilitate the search, should one or two be covered up or lost. The distances and courses, however, are always given in the description of stations.

Too great care cannot be taken for the security and identification of the station.

THE OBSERVATIONS AND RECORDS.

Two classes of theodolites are employed in the triangulation:

I. Direction instruments, with circles from 8 to 20 inches in diameter, and armed with either two or three micrometer microscopes for close reading. These are devoted almost exclusively to the primary work.

II. Repeating instruments, with circles from 8 to 12 inches in diameter, and supplied with either two or three verniers.

The record books, octavo for both the originals and duplicates, are prepared with printed headings for the different columns, showing the order in which the details are to be entered.

Form of record for direction instruments.

[Station, Blue Hill, Mass. Date, September 25, 1845. Observer, A. D. B. Recorder, C. A. Instrument No. 1, 30-inch. Position IV.]

Series and number.	Object observed.	Time.	Tel.	Mic.	°	′	d	d	Mean.	Correction for run.	Corrected mean.	Remarks.
		h. m.										
IV	Azimuth mark.	8 43	D	A	271	31	49.0	50.2				Position 0° upon 120°.
21	d. st.			B			55.0	55.0				Levels { A 73^d. B 99.
				C			60.2	62.0				
							54.7	55.7	55.2	−.1	55.1	Temp. 59° F.
22	Manomet H.	47	D	A	35	26	48.4	49.2				Atmospheric pressure.
	m. l.; m. ro.; st.			B			50.5	51.8				Weather foggy, ci.-cu.
				C			56.0	58.0				Wind N. E., light.
							51.6	53.0	52.3	−.1	52.2	
23	Manomet H.	50	R	A	215	26	37.0	40.0				
	As before.			B			39.0	41.8				
				C			48.0	46.8				
							41.3	42.9	42.1	−.2	41.9	
24	Azimuth mark.	52	R	A	91	31	44.0	44.0				
	d. m. st.			B			43.0	45.0				
				C			49.0	51.0				
							45.3	46.7	46.0	−.2	45.8	
25	Thompson H.	9 02	R	A	124	50	38.0	39.0				
	sm.; ro.; st.			B			40.8	41.0				
				C			50.0	51.0				
							42.9	43.7	43.3	−.5	42.8	
26	Etc., etc.											N. B.—Microscopes adjusted for position and run, September 16, 1845 300 div. of micr. = 301″.2 = mean of three microscopes.

The progress of the work is advanced by the use of a reference mark, to which all the other directions are referred. This mark may be the meridian or azimuth mark used in the determination of the astronomical azimuth, or one of the regular signals likely to be the most constantly visible and distinct, or one specially set up and firmly secured for the purpose, and as near as possible in the mean plane of the series of signals to be observed upon.

Form of record for repeating instruments.

[Mount Rafinesque, New York, August 21, 1875. Observer, R. D. C. Recorder, I. F. P. Theodolite No. 18, 12-inch.]

Stations.	Time.	D R	Repetitions.	A	B	C	D	Mean of verniers.	Angles.	Mean of D and R.	Remarks.
	h. m.			° ′ ″	′ ″	′ ″		″	° ′ ″	° ′ ″	
Mount Equinox.	7 05 a. m.			70 04 13	04 35	04 32		26.6			
Greylock.									70 26 17.5		
		D	3	281 23 10	23 35	23 12		19.0		70 26 15.8	
									14.0		
Do.		R	3	132 41 52.5	42 21	41 58		03.8			
				132 41 52.5	42 21	41 58		03.8			
									70 26 17.6		
Do.		R	3	344 00 45	01 05	01 00		56.7		70 26 16.8	
									16.1		
		D	3	195 19 36	19 53	19 46		45.0			
Greylock.	7 30 a. m.			195 19 36	19 53	19 46		45.0			
Perry's Peak.									40 06 53.9		
		D	3	315 40 20	40 35	40 25		26.7		40 06 54.7	
									55.5		
Do.		R	3	76 01 05	01 20	01 15		13.3			
				76 01 05	01 20	01 15		13.3			
									40 06 55.2		
Do.		R	3	196 21 51	22 10	21 56		59.0		40 06 55.1	
									55.1		
		D	3	316 42 38	42 50	42 45		44.3			

Uniformity in the method of observing and of recording the observations should be strictly observed.

1. The number of the theodolite, the diameter of its circle, and the order of its graduation, whether from left to right or from right to left, should be entered at the commencement of each volume.

2. The angles should be measured in the direction of the increasing numbers on the circle, so that, with telescope direct, the first reading may be subtracted from the second. The station first pointed at should be the first named.

After observing a series of directions, say from A to F, the pointings, telescope reversed, should be from F to A, or over the same arcs, but in reverse order.

3. If the telescope cannot be reversed except by being lifted from its supports, the microscopes or verniers should be reread after reversal.

4. If a repeating instrument is employed, the pointings should be so arranged as to fall upon as many different parts of the circle as the size of the angle and the proposed number of measurements will permit, in order to eliminate any possible error of graduation or eccentricity.

In the case of a direction instrument, the same object is accomplished by changing the position of the circle. This is done by means of the revolving stand, or by turning the circle in its collar. The number of these changes or positions will depend upon the size and character of the graduation of the circle, but it must always be a prime number, such as either 5, 7, 11, 13, 17, 19, or 23. The circle, or 360°, is then divided by the prime number adopted, and the resulting number of degrees and minutes will be the quantity to be moved forward for each new position.

5. The closing of the circle, or the measurement of the angle between the last station and the first, should be made with the same care and number of repetitions with which the regular angles were determined.

6. Should the theodolite, or the object observed upon, be eccentric, the fact or facts should be mentioned on the proper page of the record, and a plan and the necessary data for correcting the directions or angles should be clearly presented on one of the blank pages at the commencement of the volume.

7. When a correction for phase becomes necessary the angle between the signal and the sun and the time should be recorded opposite to the observation to which it belongs. The form and dimensions of the tin cone or other reflector should be included.

8. The observations should always follow in the record in the order in which they were taken; and each book should be filled up, one station following the other, in the order of time, until the close of the season.

9. While order and clearness in the record should not be endangered for the sake of economy in pages, unnecessary space between the observations should be equally avoided in order not to increase the number of volumes.

It would add to the completeness of the records if a rough plan of the triangulation executed during the season should be drawn in or attached to the first volume; and, also, if at the commencement of each station, the telescope fixed at zero should be pointed at the first station, and then, following the graduation, to the next, and so on to the starting point, completing the horizon and recording the reading in each case, so as to obtain the approximate angles and the relative direction of each station.

The following abbreviations denoting the kind of signal observed upon, its appearance, &c., are those generally adopted in the survey. Too great detail in this matter is not considered necessary, having no weight in the computations; in cases where the angle is really believed to be affected by the condition of the atmosphere in either magnifying, distorting, or giving too great motion to the signal, the observer will say so, and, after giving his reasons, will reject the observations; and if he does not, the computer is rarely, if ever, authorized to do so.

ABBREVIATIONS.

SIGNAL.		DEGREE OF VISIBILITY.	
Heliotrope	H.	Distinct	dt.
Cone	C.	Bright	br.
Pole	P.	Faint	ft.
Tuft	T.	Flaming	fl.
Crotch	Cr.	Diffuse	dif.

STEADINESS.		WEATHER.	
Steady	st.	Clear	cl.
Tremulous	tr.	Flying clouds	fy. cl.
Moving	mg.	Cloudy	cly.

FIGURE.		SIZE.	
Round	r.	Point	pt.
Oval	ov.	Small	sm.
Irregular	ir.	Large	lg.

CORRECTION FOR ERROR OF RUNS.

No special form is required for the observations to determine the errors of run of the reading microscopes. Such observations are entered in the record as they are made, generally on first occupying a station, and principally for the purpose of verifying the imposed condition that the adjustment of the microscopes to the graduation of the instrument should be so far perfected that five revolutions of the micrometer screw do not overrun or underrun a five-minute space on the circle by a greater error than two seconds.

The regular observations or readings on all parts of the circle taken during the occupation of the station will supply the data for determining the mean error of runs to be used in the correction of those observations.

a. First reading. Turn the micrometer screw in the direction of the increasing numbers on its head, until the cross-wire intersects the nearest five-minute division on the circle, and read and record the number of turns and parts of a revolution.

b. Second reading. Reverse the movement of the screw and continue the backward motion of the cross-wire until it reaches the nearest five-minute division, and record as before.

Let the following data represent the mean of a number of observations taken from the record, the degrees and minutes read off from the circle being 65° 20′. As the micrometer overruns, the correction is subtractive from the mean of the two readings.

$$a = 65^\circ\ 20' + \ 4'\ 42''.6 \qquad\qquad r = a - b = + \ 0'\ 1''.8$$

$$b = 65^\circ\ 20' + \ 4'\ 40''.8 \qquad\qquad m = \frac{a+b}{2} = \ 4'\ 41''.7$$

$$\text{Correction to } a = \frac{r}{300''}\,a \ldots\ldots\ldots\ldots = - \quad 1.70$$

$$\text{Correction to } b = \frac{r}{300''} = (b - 300'') \ldots\ldots\ldots\ldots = + \quad 0.12$$

$$\text{Correction to } m = \tfrac{1}{2}\left(\frac{a + b - 300''}{300''}\right) r \ldots\ldots\ldots\ldots = - \quad 0.79$$

and, hence, the corrected mean of the two readings = 65° 24′ 40″.9.

Tables of double entry are constructed, by means of which the corrections for run can be taken out by inspection. The arguments are the number of minutes and seconds in the observation and the value of $\pm r$.

NUMBER OF OBSERVATIONS.

The number of observations required for the determination of any one direction or angle must depend upon the desired closeness of result and the character of the instrument. Each observation consists of two pointings, one in the direct and the other in the reversed position of the telescope.

If the number of positions adopted for the instrument be seven—equivalent to an advance of 51° 26′ for each change—there should be not less than five observations in each position, or thirty-five determinations for each direction. See Nos. 2 and 4, of observations and records.

When repeating theodolites are employed for the primary work, the number of measurements of each angle varies from 90 to 120, divided into sets of three or six repetitions, direct, and the same number, reversed. In the secondary triangulation, in which the length of the sides varies from 5 to 40 miles, and especially in cases where such triangulation is the most extended which the nature of the country will admit of, and the results of which become, in consequence, of primary importance, the angle should be determined by not less than six sets, each consisting of six repetitions in the direct and six in the reversed position of the telescope, or twelve sets of three in the D and three in the R. If the triangles belong to the tertiary series, the sides being 5 miles and under in length, the number of sets will vary from three to six, according to the distance along the coast over which the chain will extend before a verification can be effected by connection with a line of the secondary triangulation, or by the measurement of a subsidiary base. In this class of angles, each set is made up of three repetitions in the D and three in the R, in order to increase the number of separate results with a view to comparison and the elimination of error.

While a minimum number of measurements may be prescribed for each angle belonging to the orders of triangulation referred to, the maximum must be left entirely to the judgment of the observer. In forming this judgment, the known or supposed character of the instrument in regard to accuracy of graduation or the reverse; the elevation of the instrument; the differently refracting media through which the line of sight passes, as over alternate sections of land, marsh, and water; the lateral refraction incident to long lanes opened through the forest or swamp; the appearance of the signal, and the condition of the atmosphere, will be taken into consideration, and the observer, from one cause or another, may deem it advisable to multiply his observations until he becomes satisfied that he has obtained the value of the angle, or until an apparently discordant result is neutralized or proved to be exceptional.

In the case of auxiliary points determined with a concluded angle, such as light-houses, spires, chimneys, &c., and others especially thrown in between the secondary and tertiary stations to facilitate the operations of the topographical and hydrographical parties, a single measurement of six repetitions, three in the D and three in the R, will be sufficient. Care should be taken, however, that the unobserved angle should not greatly differ from 90°, and especially that each determination of this character should have its check or verification by a second determination from a different base.

LIMIT OF ERROR.

Assuming 3″ to be the limit of error of closing in triangles of the primary order, 6″ in those of the secondary, and about 12″ in those of the tertiary series, it is certain that to secure the desired degree of accuracy the observer should give his careful attention, seriatim, to the following points:

1. To the diameter and centering of each of the signals to be observed upon.
2. To the stability of the stand or tripod on which the theodolite rests.
3. To the centering of the instrument, and to its adjustment for parallax, collimation, and level.
4. To his personal comfort when observing, by having the eye and telescope at the same height when standing in a natural position, and by avoiding the necessity for any strain on the body or twist in the neck to look at any particular signal.
5. To the preservation of the levels while observing, and to a certain degree of rapidity in the pointing consistent with a clear and decided bisection of the signal.
6. To taking the different sets required for the determination of the angle, part on one day and part on another, or dividing them between the a. m. and p. m. periods for observing.
7. To declining to observe under any manifestly improper or doubtful condition of the atmosphere, as shown principally by the signals.

The observations taken on a day when the sky is entirely overcast from sunrise to sunset are the most reliable, and next in value are those taken during a calm afternoon when the sky is wholly clear. The a. m. observations, made before the sun has dissipated the vapors of the night or has quieted down the irregularities in the lower stratum of the atmosphere by an equalization of the temperature, are believed to be the most uncertain. These irregularities may be recognized by an unusual refraction or elevation of the signals above the horizon, beside the jumping duplication, or distortion of the image, and the greater the vertical refraction the greater will be the probability of a slight lateral deviation in the ray.

After the preceding precautions have been strictly observed, and the prescribed number of measurements taken, the next step will be to examine the separate values of each angle with a view to ascertain the probable accuracy of the pointings.

The probable error of an angle in the primary triangulation should not exceed 0″.3, and in the secondary 0″.7.

It is not improbable that after the prescribed number of sets has been taken, a critical examination of the values, and of the circumstances under which they were obtained, will show that additional measurements are necessary or advisable. There are other errors beside those of pointing, which, notwithstanding every precaution, may largely increase the probable error of the resulting angle. The fact of an agreement among separate measurements is not a proof of having obtained the correct value of the angle, unless those measurements were made under different conditions of the atmosphere, and during a. m. and p. m., to guard against an altogether one-sided refraction and illumination of the signal.

PROBABLE ERROR.

o, o^1, o^2, &c. =the observed values of the angle.
n =number of such values, or sets of repetitions.
x_0=their arithmetical mean.
Δ =differences between x_0 and o, o^1, &c.
Σ =symbol denoting sum.
ε =mean error.
r =probable error of any one of the observed values.
r_0=probable error of x_0.

$$\varepsilon=\sqrt{\frac{\Sigma\Delta^2}{n-1}} \qquad r=0.6745\sqrt{\frac{\Sigma\Delta^2}{n-1}} \qquad r_0=\frac{r}{\sqrt{n}}$$

o, o^1, o^2, &c.			x_0	Δ	Δ^2
°	′	″	″	″	
45	44	22.5	23.5	−1.0	1.00
		24.8		+1.3	1.69
		21.0		−2.5	6.25
		21.4		−2.1	4.41
		26.6		+4.1	16.81
		22.3		−1.2	1.44
		25.5		+2.0	4.00
		24.6		+1.1	1.21
		21.0		−2.5	6.25
		23.3		−0.2	0.04
		25.5		+2.0	4.00
		23.5		0.0	0.00
45	44	23.5		20.0	47.10

$n-1=11$	co. log 11	8.95861	
$\Sigma\Delta^2=47.10$	log 47.10	1.67302	
		0.63163	
	log ε	0.31582	$\varepsilon=$ 2″.07
Const. .6745	log const	9.82998	
	log r	0.14580	$r=\pm1''.40$
	log $\sqrt{12}$	0.53959	
	log r_0	9.60621	$r_0=\pm0''.40$

Or, using only the differences or residuals, according to the formulæ given by C. A. Schott, page 308 Coast Survey Report of 1856, and without employing logarithms,

$$r=0.845347\frac{\Sigma\Delta}{\sqrt{n(n-1)}},\ \text{or}\ r=0.84\frac{\Sigma\Delta}{n-1} \qquad r=0.845\frac{20}{11.49}=1''.47$$

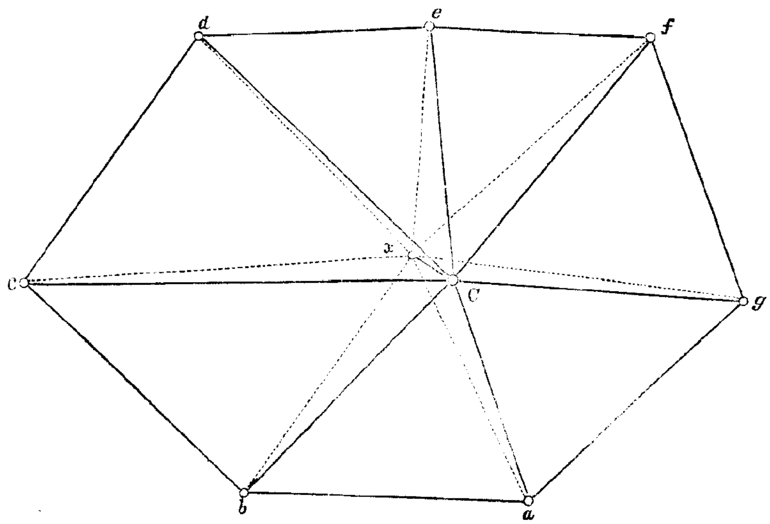
$$r_0=\frac{r}{\sqrt{n}} \qquad r_0=\frac{1.47}{\sqrt{12}}=0''.42$$

The number of measurements required for each angle having been taken, the next step will be to apply to each, or to their arithmetical mean, as the case may be, the corrections for phase, or eccentricity of the object observed upon, or those due to the occupation of an eccentric station. The angles in the abstract being corrected accordingly, if any such correction should be necessary, the final computation of the triangle sides will be commenced by computing the spherical excess, and by the distribution among the angles of the error found in the triangle.

The example given in illustration of the following formulæ for reduction to center of station, phase in tin cone, eccentricity of signal, and spherical excess, are believed to cover every possible case.

REDUCTION TO CENTER OF STATION.

When the center of the station cannot be occupied, the theodolite is adjusted at a point as close as possible to the center, which new point is called the eccentric station. To be able to reduce the angles measured at the eccentric to the center of the true station, it is necessary that the distance between the two should be measured with the utmost exactness, and that the angle at x, between the true center and one of the stations of the triangle, be carefully determined.



C = center of station.
x = eccentric position of instrument.
r = the distance Cx.
o = the angle at x between two signals, a and b.
y' = the angle at x between C and the left-hand signal a.
a = the distance Ca.
b = the distance Cb. log sin 1″ = 4.6855749
C = the unknown angle at C. co. log sin 1″ = 5.3144251

The signals are all supposed to be situated to the right of C, following each other in azimuthal order.

$$C = o + \frac{r \sin (o+y')}{b \sin 1''} - \frac{r \sin y'}{a \sin 1''}$$

The sign given for each term of the formula will be governed by that of the sine of $o+y$ and of y'.

Example.—Triangle axb.

$r=2^m.2145$ .... log r ..	0. 3452757	$r=2^m.2145$ .... log r ..	0. 3452757
$o+y'=89°\ 45'\ 20''$; log sin $(0+y')$ ..	9. 9999960+	$y'=28°29'30''$; log sin y' ..	9. 6785465+
co. log b	6. 0855685	co. log a	6. 1870866
co. log sin 1″	5. 3144251	co. log sin 1″	5. 3144251
	1. 7455653 .. +55″. 66		1. 5253339 .. −33″.52
	−33″. 52		

C=61° 15′ 50″+22″. 14=61° 16′ 12″.14

Example.—Triangle exg.

$r=2^m.2145$ .... log r ..	0.3452757	$r=2^m.2145$ ...... log r ..	0.3452757
$o+y^5=330°20'40''$; log sin$(0+y')$	9.6944163−	$y^5=236°\ 24'\ 15''$ log y^5 ..	9.9206249−
co. log g	6.0910863	co. log e	6.1429692
co. log sin 1″	5.3144251	co. log sin 1″	5.3144251
	1.4452034 .. −27″.87		1.7232949 ... +52″.88
	+52″.88		

C=93° 56′ 25″ +25″.01=93° 56′ 50″.01

When a large number of angles have been observed at an eccentric station, and different combinations are required, it is recommended that the directions to the different signals be arranged in the order of their azimuths, starting from the line xc, as shown in the following example, and that the correction for each line be computed by the formula

$$\frac{r \sin y^1}{a \sin 1''}$$

Angle.	Under 180°.	Over 180°.
$(o+y)$	+	−
y^1	−	+

By adding or subtracting the corrections for the two lines inclosing the special angle according to the signs given in this table, the reduction to the center and its sign will be obtained. The direction to the right-hand signal always represents $(o+y)$.

Example.

	x to C 0° or 180°	x to a y^1	x to b y^2	x to c y^3	x to d y^4	x to e y^5	x to f y^6	x to g y^7
Direction.	00°00′ 00″	28°29′ 30″	89°45′ 20″	139°28′ 40″	185°32′ 10″	236°24′ 15″	280°14′ 50″	330°20′ 40″
Log Sine		9. 67855	9. 99999	9. 81274	8. 98441	9. 92062	9. 99302	9. 69442
Log r		0. 34528	0. 34528	0. 34528	0. 34528	0. 34528	0. 34528	0. 34528
Co. log. dist.		6. 18709	6. 08587	5. 92010	5. 99965	6. 14297	6. 04576	6. 09109
Co. log sin 1″		5. 31443	5. 31443	5. 31443	5. 31443	5. 31443	5. 31443	5. 31443
		1. 52535	1. 74557	1. 39255	0. 64377	1. 72330	1. 69849	1. 44522
Correction.		a=33.″52	b=55.″66	c=24.″69	d=4.″40	e=52.″88	f=49.″94	g=27.″88

Hence, the corrections would be, for the angle between

		″	″		°	′	″	″	°	′	″
a and b	=	+55.66	−33.52	and C=	61	15	50	+22.14=	61	16	12.14
a and c	=	+24.69	−33.52	and C=	110	59	10	− 8.83=	110	59	01.17
a and d	=	− 4.40	−33.52	and C=	157	02	40	−37.92=	157	02	02.08
c and e	=	−52.88	−24.69	and C=	96	55	35	−77.57=	96	54	17.43
f and g	=	−27.88	+49.94	and C=	50	05	50	+22.06=	50	06	12.06
g and a	=	+33.52	+27.88	and C=	58	08	50	+61.40=	58	09	51.40
f and a	=	+33.52	+49.94	and C=	108	14	40	+83.46=	108	16	03.46

The above eccentricity may be considered much greater than the average. Occasionally it is very small, as when, by some mistake, the instrument, mounted on a high tripod, cannot be adjusted exactly over the center of station, but a few inches off, in one direction or the other. The distance and direction, in all cases, should be most carefully determined; and, if the eccentricity is large, the triangle sides, or distances, should be recomputed with the observed angles corrected by an approximate reduction to the center.

CORRECTION FOR PHASE IN TIN CONES USED AS SIGNALS.

x=station of observer.
C=the sun; or, xC, the azimuth of sun.
y=angle between sun and reflecting cone.
a=distance between observer and cone.
r=mean radius of cone.

If the pointing is made on the bright reflecting line exhibited by the cone, then

$$\text{correction} = \pm \frac{r \cos \frac{1}{2}y}{a \sin 1''}$$

but if there is no such reflection, and the pointing be made on the white illuminated part of the cone,

$$\text{correction} = \pm \frac{r \cos \frac{1}{2}y}{a \sin 1''}$$

Examples.

Bright phase.

$r=0^m.215$	log r	9.33244
$y=89^\circ\ 40'$,	log cos $\frac{1}{2}$ $89^\circ\ 40'$	9.85074
$a=18206^m$	co. log 18206	5.73979
	co. log sin $1''$	5.31443
correction $=1''.72$		0.23740
$r=0^m.215$	log r	9.33244
$y=176^\circ$,	log cos $\frac{1}{2}$ 176°	8.54282
$a=18206^m$,	co. log 18206^m	5.73979
	co. log sin $1''$	5.31443
correction $=0''.08$		8.92948

White phase.

$r=0^m.215$	log r	9.33244
$y=89^\circ\ 40'$,	log cos $\frac{1}{2}$ $89^\circ\ 40'$	9.85074
	log cos $\frac{1}{2}$ $89^\circ\ 40'$	9.85074
$a=18206^m$,	co. log 18206	5.73979
	co. log sin $1''$	5.31443
correction $=1''.22$		0.08814
$r=0^m.215$	log r	9.33244
$y=176^\circ$,	log cos $\frac{1}{2}$ 176°	8.54282
	log cos $\frac{1}{2}$ 176°	8.54282
$a=18206^m$,	co. log 18206	5.73979
	co. log sin $1''$	5.31443
correction $=0''.003$		7.47230

The bright phase belongs exclusively to the curved cones usually employed as signals in the primary and secondary triangulation.

The line of reflection, or the illumination, is always on the same side with the sun. If, therefore, the direction to the second signal is on the same side of the reflecting cone as the sun, the correction is additive to the observed angle; if on the opposite side, subtractive. If both signals are reflecting, or illuminated cones, the difference between the two additive or subtractive corrections, as the case may be, is the correction to be applied $\pm$ to the angle.

The angle between the sun and the signal should be measured immediately after completing the set of repetitions to which the correction must be applied. Should the angle be omitted, but the time be recorded, the azimuth of the sun may be computed. It should also be matter of record whether the cone reflects or merely shows white.

CORRECTION FOR ECCENTRICITY OF SIGNAL.

C = center of station.
x = the eccentric object, or part of signal observed upon.
r = the measured eccentricity.
a = the station of observer; also, the distance of aC.

$$\text{Correction} = \pm \frac{r}{a \sin 1''}$$

Let us suppose, for example, that, during the occupation of the stations a, b, c, and d, of the preceding diagram, the pole at C was out of adjustment, or that x, the object observed upon, was not in the vertical of C, and that, to correct the error, the following measurements were made of the chord, or the perpendicular, from C to the different directions, viz: $0^m.155$, $0^m.293$, $0^m.182$, and $0^m.096$.

$r = 0^m.155$,	log r	9.19033
$a \doteq 6500^m$,	log a sin $1''$	8.49849
correction $= 4''.92$		0.69185
$r = 0^m.182$,	log r	9.26007
$c = 1220^m$,	log c sin $1''$	8.76548
correction $= 3''.12$		0.49459

$r = 0^m.293$,	log r	9.46687
$b = 8206^m$,	log b sin $1''$	8.59971
correction $= 7''.36$		0.86716
$r = 0^m.096$,	log r	8.98227
$d = 1008^m$,	log d sin $1''$	8.68592
correction $= 1''.98$		0.29635

Hence, in the triangles aCb, bCc, and cCd, the corrections to the observed angles should be

	$''$		$''$		$''$
For Cab	+ 4.92	Cbc	+ 7.36	Ccd	+ 3.12
For Cba	− 7.36	Ccb	− 3.12	Cdc	+ 1.98

SPHERICAL EXCESS.

Every angle measured in the ordinary operations of geodesy is a spherical angle, and consequently the sum of the three observed angles of any triangle should, theoretically, exceed 180°. This spherical excess, or ratio of the area of the triangle to the area of the sphere, becomes appreciable only when the sides are from four to five miles in length; and being so small a quantity in proportion to the errors of observation, it is entirely overlooked in triangles of the third order.

In the secondary and primary triangulation, the spherical excess is applied to determine the error due directly to the observations. One-third of the computed excess is deducted from each angle of the triangle, and the difference between the resulting sum of the angles and 180° is the error to be distributed. The values of A and B are those deduced by Col. A. R. Clarke, R. E., from a combination of all the best measured arcs up to 1866.

Let a, b = triangle sides.

C = the included angle.

		log's.
A = equatorial radius	$6378206^{m}.4$,	6.8046985
B = polar radius	$6356583^{m}.8$,	6.8032238

e = the eccentricity $= \sqrt{1 - \frac{B^2}{A^2}}$

$e^2 = 0.00676815$ 7.8304700

L = mean latitude of the three stations.

$$\varepsilon = \frac{ab \sin C\,(1 + e^2 \cos 2L)}{2A^2 \sin 1''}, \text{ and making } m = \frac{1 + e^2 \cos 2L}{2A^2 \sin 1''},$$

we have $\varepsilon = ab \sin Cm$.

The latitude being the only variable quantity in the formula m, we make the latter a constant by computing it for every 30′ of latitude likely to be embraced in the survey, and tabulate the results. The value of m for intermediate latitudes may be taken out by inspection, though such precision is only necessary in the very largest triangles.

Computation of m.

$L=24°$, $2L=48°$, $\log \cos 2L=9.8255109$

e^2, $\log e^2 = 7.8304700$

$\log e^2 \cos 2L = 7.6559809$

$e^2 \cos 2L = 0.0045288$

$1+e^2 \cos 2L = 1.0045288$

$\log (1+e^2 \cos 2L) = 0.0019624$

$\log (2\,A^2 \sin 1'') = 8.5960019$

$\log m$ for lat. $24° = 1.4059605$

$\log \sin 1'' = 4.6855749$

$\log A^2 = 3.6093970$

$\log 2 = 0.3010300$

$\log (2\,A^2 \sin 1'') = 8.5960019$

Latitude.	log m.	Latitude.	log m.	Latitude.	log m.	Latitude.	log m.
24° 00′	1.40596	31° 30′	1.40533	30° 00′	1.40461	46° 30′	1.40385
24 30	592	32 00	528	39 30	456	47 00	380
25 00	588	32 30	524	40 00	451	47 30	375
25 30	584	33 00	519	40 30	446	48 00	369
26 00	580	33 30	514	41 00	441	48 30	364
26 30	576	34 00	509	41 30	436	49 00	359
27 00	572	34 30	505	42 00	431	49 30	354
27 30	568	35 00	500	42 30	426	50 00	349
28 00	564	35 30	495	43 00	420	50 30	344
28 30	559	36 00	491	43 30	415	51 00	339
29 00	555	36 30	486	44 00	410	51 30	334
29 30	551	37 00	481	44 30	405	52 00	329
30 00	547	37 30	476	45 00	400	52 30	324
30 30	542	38 00	471	45 30	395	53 00	319
31 00	1.40537	38 30	1.40466	46 00	1.40390	53 30	1.40314

The above table is computed on Clarke's spheroid. To refer it to Bessel's spheroid, increase log m in the 5th place of decimals by—

9 for latitude......	25°	10 for latitude......	40°
9 for latitude......	30°	11 for latitude......	45°
10 for latitude......	35°	12 for latitude... ..	50°

Computation of spherical excess.

$a = 6500^{m}$,	log a......	3.81291	$a = 122755^{m}$,	log a......	5.08904
$b = 4615^{m}.6$	log b......	3.66423	$b = 94616^{m}$,	log b	4.97596
$C = 61° 15' 50''$,	log sin c...	9.94292	$C = 50° 10' 20''$,	log sin c...	9.88535
m for 36° L.,	log m......	1.40491	m for 45° 15′ L.,	log m......	1.40398
$\varepsilon = 0''.07$		8.22497	$\varepsilon = 22''.61$		1.35433

DISTRIBUTION OF ERROR.

In the primary series the errors are adjusted by the application of the method of least squares, as explained and exemplified in appendices Nos. 33 and 14, Annual Reports for 1854 and 1864; or distributed in proportion to the probable error of each angle as determined directly from the measures of the angles.

In the secondary triangulation the error is distributed as above, or in inverse proportion to the number of measures taken of each angle, or, in less important cases, equally among the three angles.

In triangles of the third order the error, as a rule, is equally distributed among the three angles.

ABSTRACTS AND COMPUTATIONS.

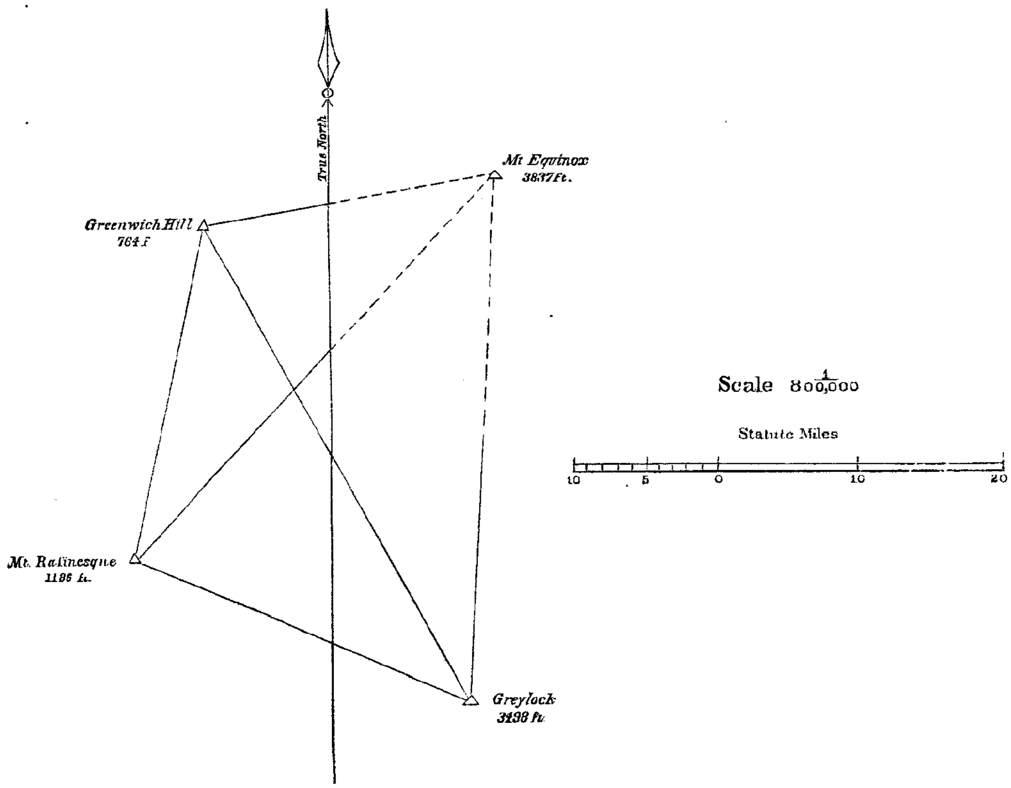
Form for abstract of angles.

[Station, Mount Rafinesque, New York.—Instrument, theodolite No. 18.]

Date.	A. M. or P. M.	Stations observed.	Tel.	No. of rep.	Angle.	Mean of D and R.	Corr.	Mean angle.
	h. m.				° ′ ″	″	″	° ′ ″
Aug. 6	5 40 a. m	Greenwich Hill.....	D	6	32 48 57.6			
6	....	Mount Equinox.....	R	6	59.2	58.4	....	32 48 58.4
6	....	....do	D	6	57.2			
6	....	....do	R	6	57.4	57.3	....	57.3
Aug. 7	5 00 p. m	....do	D	6	57.8			
7	....	....do	R	6	59.0	58.4	*—0.1	58.3
7	....	....do	D	6	56.8			
7	....	....do	R	6	57.2	57.0	*—0.1	56.9
Aug. 9	6 00 a. m	....do	D	6	58.3			
9	....	....do	R	6	59.5	58.9	....	58.9
Aug. 10	6 10 p. m	.. do	D	6	57.3			
10	....	....do	R	8	58.4	57.9	....	57.9
								32 48 57.95
Correction for eccentricity of instrument..........								+0.37
								32 48 58.32
Helderberg, &c., &c								
Greenwich								

* For phase.

The preceding form shows the application of the corrections for phase or eccentricity, and the one which follows, the spherical excess and distribution of error. It will be noticed that the station of Mount Equinox has not been occupied, and, hence, the angle is marked c for "concluded." In the arrangement of the triangles for computation, whether belonging to a quadrilateral or not, the station to be determined from the base being the first named, is termed the apex; and from this apex, the other two stations must be invariably entered in their azimuthal order, that is, from left to right.



Form for computation of triangle sides.

SECONDARY QUADRILATERAL.

Denomination.		Observed angles.	Corr'n.	Spher'l angles.	Spher'l angles.	Plane angles and distances.	Logarithms.
						m.	
		Greylock to Mount Rafinesque				40540.16	4.6078854
Greenwich Hill	76	39 43 31.63	+ 0.32	31''.95	− 1.27	39 43 30.68	0.1944271
Greylock	67	37 01 16.33	+ 0.32	16''.65	− 1.27	37 01 15.39	9.7796731
Mount Rafinesque	62	103 15 14.88	+ 0.32	15''.21	− 1.27	103 15 13.93	9.9882752
		Greenwich Hill to Mount Rafinesque				38193.16	4.5819856
		Greenwich Hill to Greylock				61743.00	4.8905877
		Greylock to Mount Rafinesque					4.6078854
Mount Equinox	c			36.46	− 1.89	40 26 34.57	0.1879625
Greylock	99	69 07 12.65			− 1.89	69 07 10.76	9.9704986
Mount Rafinesque	65	70 26 16.56			− 1.89	70 26 14.67	9.9741783
		Mount Equinox to Mount Rafinesque				58391.08	4.7663465
		Mount Equinox to Greylock				58887.97	4.7700265
		Mount Equinox to Greylock					4.7700265
Greenwich Hill	74	69 14 52.77			− 1.63	69 14 51.14	0.0291327
Mount Equinox	c			15.80	− 1.63	78 39 14.17	9.9914285
Greylock	67	32 05 56.32			− 1.63	32 05 54.69	9.7254026
		Greenwich Hill to Greylock				61743.00	4.7905877
		Greenwich Hill to Mount Equinox				33462.76	4 5245618
		Mount Rafinesque to Greenwich Hill					4.5819856
Mount Equinox	c			40.34	− 1.02	38 12 39.32	0.2086194
Mount Rafinesque	74	32 48 58.32			− 1.02	32 48 57.30	9.7339526
Greenwich Hill	73	108 58 24.40			− 1.02	108 58 23.38	9.9757401
		Mount Equinox to Greenwich Hill				33462.44	4.5245576
		Mount Equinox to Mount Rafinesque				58390 90	4.7663451

COMPUTATIONS OF THE GEODETIC LATITUDE (L), LONGITUDE (M), AND AZIMUTH (Z).

The formulæ, tables, and examples for the computation of the geodetic latitudes, longitudes, and azimuths are given and fully explained in appendix No. 19, Coast Survey Annual Report for 1860.

For the sake of easy reference during the rapid and numerous computations of this character required from the assistant in the field, the signs, and their application, of the corrections depending on the relation of the given azimuth to the different quadrants, and on the algebraic signs of dL and dZ, are tabulated as follows:

Corrections to given Latitude.	
Z= 0° to 90° Z=270 to 360 d L subtractive from L.	Z= 90° to 180° Z=180 to 270 d L additive to L.
″ +1853.590 + 22.760 + 0.084 − 0.268	″ −448.308 + .051 + .005 + .000
$-d$ L=+1876.166	$-d$ L=−448.252

Corrections to given Longitude.
Z= 0° to 90° Z=90 to 180 d M additive to M.
Z=180° to 270° Z=270 to 360 d M subtractive from M.

Corrections to given Azimuth.
Z= 0° to 90° Z=90 to 180 d Z subtractive from Z.
Z=180° to 270° Z=270 to 360 d Z additive to Z.

The angles used in the above computations are the spherical angles taken from the computation of triangle sides.

In the computations for L, M, Z, the first computation should be made on the left-hand page of the form, and the second, or check computation, on the opposite page.

Previous to February 4, 1880, the above computations were based upon the elements of Bessel's spheroid. Hereafter, they will be invariably made in accordance with Clarke's spheroid. The corrections, required by this change, to the values of the coefficients A, B, C, D, and E, as published in appendix 19, 1875, are readily obtained from the subsidiary table given in the same appendix.

SPIRIT-LEVELING.

The spirit-level is employed to determine the height, above mean tide, of the principal triangulation stations on the coast, to serve as bases for the trigonometrical leveling, and, indirectly, the coefficient of refraction; and, also, the difference in height of the mean tide at different localities for use in the discussion of the tides.

To obtain the required degree of accuracy and confidence in the results, the following system has been adopted:

I. The line starts from a bench-mark on the coast, the height of which above the mean tide has been determined by observations during not less than a semi-lunation.

II. The line is re-leveled in an opposite direction; or, in other words, the route is divided into short sections, and each section is leveled, forward and back, before proceeding to the next. The intermediate bench-marks supply intermediate checks.

III. The instrument and the method of observing and recording are so arranged as to secure the adjustment of the instrument or its equivalent, checks upon the leveling, and precision in the results.

The details of the above operations are given in the "general directions for running a line of levels." It is proposed here simply to refer to III.

The spirit-level, whether of the pivot or ordinary construction, has the diaphragm of its telescope provided with a reticule of two vertical and three horizontal wires.

The leveling-rod is carefully divided at the office into metres, decimetres, centimetres, and half-centimetres, and is provided with two small levels inserted in the rod, with which to preserve its verticality when held upon the foot-plate.

The foot plate is of iron, triangular in shape, with a circular cavity in which the rounded extremity of the rod rests, and with three short legs, by means of which the plate can be firmly planted in the ground by a stamp of the foot. A light chain and ring is attached to the plate by which the rodman can pull it up and carry it on to the next station.

Three leveling-rods and three foot-plates belong to the party, one set being held in reserve in case of accident to either of those in use.

The observer reads and records the heights on the rod crossed by the three wires, estimating the millimetres, or he can use a target, and a record of the readings be kept by both the observer and rodman. The condition of the level at every observation is entered in the record.

The instrument should be, theoretically, midway between the rods, and the distance from instrument to rod should rarely exceed 100 metres.

Before commencing the leveling, the value of the constants belonging to the particular instrument, and which are required for the reduction of the observations, are carefully determined.

CONSTANTS.

L	value of one division of level	3″.5
a_1 and a_2	angular distances between the wires	207″.01 and 198″.95
A	angular distance between extreme wires	405″.96
m	for reducing mean of three wires to middle wire..	2″.6867

To ascertain the angular distances, select a level spot of ground and measure off, with all possible care, distances from the instrument of 50, 100, 150, and 200 metres; adjust the instrument and read and record the heights on the rod crossed by the wires at each distance. This operation should be repeated at least four times for each distance.

Mean of four alternate readings at each distance.

50 metres.	100 metres.	150 metres.	200 metres.
m.	*m.*	*m.*	*m.*
0.0493	0.1007	0.1507	0.1997
.05033	.10067	.14967	.20067
0.0997	0.2013	0.3003	0.4003
.04833	.09766	.14300	.19233
0.1480	0.2990	0.4433	0.5927
.09866	.19833	.29267	.39300

Angular value of the distance between wires $= \dfrac{\text{difference in height}}{\text{D tang. } 1''}$, in which D represents the distance.

Difference = .05033	log Diff...	8.7018269
D = 50^{m}	co. log 50..	8.3010300
Co. log tang. 1″.	....	5.3144250
		2.3172819 207″.63 = a_1,

and so on, for the twelve differences, resulting as follows:

a_1	a_2	A
″	″	″
207.63	199.38	407.00
207.65	201.44	409.08
205.81	196.64	402.45
206.96	198.35	405.31
207.01	198.95	405.96

An error of one second in the angular value of A would produce an error of one millimetre at 200 metres, and an error in the distance of 0.5 of a metre.

$$\text{Constant } m = \frac{207''.01 - 198''.95}{3} = -2''.6867$$

The upper wire, as seen in the telescope, is, in reality, the lower wire.

The usual adjustments of the instrument are made every morning and duly entered in the record, and are repeated during the day should a change from any cause be suspected.

I. For level, or to make the axis of the level parallel with the optical axis of the telescope.

This adjustment may be incomplete, but the record will give the data for determining the error.

Level.		Level reversed.	
E	O	E	O
d	*d*	*d*	*d*
7.7	7.3	9.5	5.5
6.2	8.8	8.0	7.0
7.0	8.0	8.8	6.2
6.97	8.03	8.77	6.23

$$\frac{1''.80}{2} = +0''.9 \quad 0''.9 \times 3''.5 = +3''.15 = \text{error of level} = l.$$

II. For collimation, or to bring the middle horizontal wire and the middle of the two vertical wires in the optical axis of the telescope.

The record will also show whether this adjustment was perfect or imperfect. For instance:

	Normal position.			Turned on axis, 180°.			Normal position.		
	d	*d*	*m*	*d*	*d*	*m*	*d*	*d*	*m*
	7.5	7.5	1.105	7.4	7.6	1.100	7.0	8.0	1.106
			1.150			1.145			1.150
	8.0	7.0	1.194	9.3	5.7	1.189	7.0	8.0	1.195
			1.1497			1.1447			1.1503
Correction for inclination			+.0004			+.0013			+.0008
Reduction to mean of wires			−.0006			−.0006			−.0006
			1.1495			1.1454			1.1505
			1.1505			1.1500			
			Mean=1.1500			+0.0046			
						+0.0023=error of collimation.			

III. For verticality of axis, or to make the vertical axis of the instrument perpendicular to the axis of the level.

Form of the field-record.

BACK SIGHT.								FORE SIGHT.							
Station.	Level			Readings on rod.	Correction for inclination.	Corrected height.	Distance between extreme wires.	Station.	Level.			Readings on rod.	Correction for inclination.	Corrected height.	Distance between extreme wires.
	Eye end.	Object end.	Difference.						Eye end.	Object end.	Difference.				
	d	*d*		*m*		*m*			*d*	*d*		*m*		*m*	
Tidal B. M.	7.5	7.5		2.050				1	6.8	8.2		1.049			
				2.150								1.150			
	8.0	7.0		2.248					7.0	8.0		1.248			
	15.5	14.5	+1.0	2.1493	+ .0035	2.1528	.198		13.8	16.2	−2.4	1.1490	− .0047	1.1443	.199
			+0.5								−1.2				
1	6.1	8.9		1.049				2	7.5	7.5		1.048			
				1.099								1.098			
	6.5	8.5		1.148					9.0	6.0		1.148			
	12.6	17.4	−4.8	1.0987	− .0034	1.0953	.099		16.5	13.5	+3.0	1.0980	+ .0026	1.1006	.100
			−2.4								+1.5				
2	7.4	7.6		1.150				3	7.0	8.0		2.120			
				1.180								2.160			
	9.3	5.7		1.208					7.0	8.0		2.200			
	16.7	13.3	+3.4	1.1793	+ .0016	1.1809	.058		14.0	16.0	−2.0	2.1600	− .0018	2.1588	.080
			+1.7								−1.0				
3	7.5	7.5		2.205				4	7.5	7.5		1.196			
				2.250								1.242			
	8.0	7.0		2.294					9.0	6.0		1.287			
	15.5	14.5	+1.0	2.2497	+ .0016	2.2513	.089		16.5	13.5	+3.0	1.2417	+ .0024	1.2441	.091
			+0.5								+1.5				
						6.6803	.444							5.6478	.470

We have now:

L=one division of the level=$3''.5$.

A=angular distance between extreme wires=$405''.96$.

m=constant for reduction to middle wire=$-2''.6867$.

l=error of level=$+3''.15$.

c=error of collimation=$+0.^{m}0023$.

d=observed distance between extreme wires.

D=observed distance from instrument to rod.

i=observed inclination.

And let

I=correction for inclination.

M=correction for middle wire.

C=correction for collimation.

R=correction for inequality of distance between back and fore sights.

Correction for inclination.

$$I = i\ d \cot A \tan 1''.$$

d.	*d.*			
7.5	7.5			
8.0	7.0			
15.5	−14.5	= 0.5 × 3.50 = 1.75	= *i* ..	0.24304
2.205 −	2.294 =	0.89	= *d* ..	8.94939
		405.96	= A ..	2.70590
Tang. 1″				4.68557
			Correction = +.0004 =	6.58390

Correction to reduce mean of three wires to middle wire.

$M = d \cot A \tan m.$		log's.
$d =$	.089	8.94939
$A =$	405″.96	2.70590
$m =$	−2.6867	5.11479
correction, $= -$	.0006	6.77008

Correction for error of collimation.

$$c = \frac{c}{d} \cdot \left(\frac{\text{tang A}}{\text{tang } 1''} \cdot \frac{1}{L} \right) \text{ in level divisions.}$$

$c = +.0023$	log c	7.36173
$d =$ .089	co. log d	1.05061
$A = 405''.96$	log tang A	7.29410
	co. log tang 1″	5.31443
$\frac{1}{L} =$ 0.2857	co. log L	9.45591
correction, $= +2''.997$		0.47678

We now collect the errors from all sources expressed in terms of divisions of the level, and calling the sum i, or error of inclination, the correction is applied to the mean of the three readings in the record.

	″
Error of level, left in adjustment......	+ 3.15
Error of inclination	+ 1.75
Error of collimation.................	+ 3.00
	$i = + 7.90$

and $I = i\, d \cot A \tan 1'' = + 0.0016$.

So long as the values of L and A remain unchanged, the preceding computations are made once for all by the construction of tables from which the corrections can be taken out by inspection.

Table I.—Distance, instrument to rod, with argument d.

Table II.—Reduction to middle wire, with argument d.

Table III.—Double entry. Correction for error of inclination, with arguments i and d.

Table IV.—Double entry. Correction for collimation, with arguments c and d.

Correction for inequality of distance between the back and fore sights.

Reduction to true horizon $= (1 - 2m) \frac{D^2}{2R}$, in which

m = co efficient of refraction	.070
R = mean radius of earth	log R = 6.8039618
D = the distance	d cot A.

Reduction $= 0^{m}.000000067532\ (d \cot. A)^2$.

The maximum distance from the instrument to rod being confined, as a rule, to 100 metres, the greatest probable inequality may be assumed at 30m (.059) or 100m (.197) for the back sight and 70m (.138) for the fore sight, the correction for which would not amount to more than one-third of a millimetre. However small and inappreciable in a single case, an aggregate of such differences might have a sensible effect upon the difference of level. Let us suppose that the distance between two bench-marks was about six miles, divided into 5527 and 4127 metres, or, in other words, that the sum of the values entered in the record under the head of the extreme wires for the back sight was 10m.879 and for the fore sight 8m.123, and that the number of stations was sixty. In this case the difference on account of curvature and refraction would be 0m.9127. which, divided by the number of stations, would give 0m.0152, or 0.6 of an inch as a closely approximate correction, subtractive from the sum of the back sights. While such great inequalities in the distance between the back and fore sights are not probable, it would be advisable to make out a table of double entry, in which d_1 represents the smaller distance and d the inequality, by the following formula. The correction for the day's work or between any two bench-marks could then be taken out by inspection. The quantity taken out must still be divided by the number of stations.

$$\text{Correction} = 0^{m}.000000067532\ (d^2 + 2dd_1).$$

TRIGONOMETRICAL LEVELING.

Differences of height are determined by the measurement at one station, by means of a vertical circle, of the double zenith distance of the signal at each of the other stations.*

Another method is to measure, by means of a micrometer inserted in the eye-piece of the telescope of the theodolite employed for horizontal angles, the differences in altitude between the different stations, expressed in minutes and seconds of arc, in connection with one or more of the stations, or a reference mark, the absolute height of which, or its zenith distance, has been obtained.

A similar series of observations being taken at each successive station, and assuming that we start from one the exact height of which above mean tide has been determined by the spirit-level, we obtain checks, or different values for the elevations, rarely exceeding 3″ to 5″ in arc, and these errors are finally assigned to their probable true place by the method of least squares.

The state of the level at the commencement and end of the observation, and the hour and minute at which it was made, are entered in the record, and also the observations made to determine the value, in seconds of arc, of one turn of the micrometer screw.

The height of the telescope above the ground at each station occupied, and of all the signals or objects observed upon, should be carefully measured and made part of the record.

The following example of the abstract for vertical angles will show the data which are indispensable, and, incidentally, the fact that by reducing, at the outset, the observed zenith distance to the ground at each station, some labor and possible complication are saved in the final computations. The correction for error of level and of inclination, taken out from a table constructed for the purpose, is applied in the record, and this corrected zenith distance is called in the abstract the observed zenith distance.

To convert the difference in metres between the height of the telescope and of the object observed upon into seconds of arc:

Seconds of arc $= \dfrac{r}{K \sin 1''}$, in which r represents the difference in metres, and K the distance between the two stations.

Abstract of results for vertical angles.

[Station, Helderberg.—Instrument, Repsold, No. 17.]

MOUNT RAFINESQUE.

Date.	Hour of day.	Object observed upon.	Above station marks. Object.	Above station marks. Telescope.	Correction. Feet.	Correction. Seconds.	Observed zenith distances.	No. of reps.	Zenith distances between station marks.	
1876.	h. m.		Feet.	Feet.	Feet.	+	° ′ ″		° ′ ″	
September 21	2 30 p. m.	Apex of tripod	22.15	6.0	16.15	27.5.	90 25 49.7	5	90 26 17.2	} *
21	4 40 p. m.	do	22.15	6.0	16.15	27.5	43.9	5	11.4	}
25	4 20 p. m.	Center of cone	43.67	6.0	37.67	64.0	17.0	5	21.0	
24	3 10 p. m.	do	43.67	6.0	37.67	64.0	08.5	5	12.5	
25	11 a. m.	do	43.67	6.0	37.67	64.0	01.1	4	05.1	
25	1 15 p. m.	do	43.67	6.0	37.67	64.0	20.6	5	24.6	}
25	2 05 p. m.	do	43.67	6.0	37.67	64.0	20.7	5	24.7	} *
25	2 45 p. m.	do	43.67	6.0	37.67	64.0	21.7	5	25.7	}
28	2 50 p. m.	do	43.67	6.0	37.67	64.0	19.8	5	23.8	
29	2 50 p. m.	do	43.67	6.0	37.67	64.0	27.9	5	31.9	
October 4	3 05 p. m.	do	43.67	6.0	37.67	64.0	12.9	5	16.0	
6	2 35 p. m.	Apex of tripod	22.15	6.0	16.15	27.5	47.0	5	14.5	
Mean									90 26 18.8	

* The results in brackets were obtained within so short a period of time, one from the other, that they must be considered in each case as a single result, or expression of the atmospheric refraction.

* See Appendices 16, 17, and 18, 1876, for office discussion of the field-work.

Form for micrometrical differences of height.

[Station, Flat Top, Va.—Date, June 24, 1876.—Observer, A. T. M.—Instrument, 14-inch Würdemann theodolite, No. 10.]

Object observed.	Time.	Level.		Micr.	Remarks.
		O	E		
SERIES IV.	*h. m.*	*d.*	*d.*	*t.*	
Tobacco Row, crotch ....v. unst..	0 28 p. m.	13. 8	11. 2	6. 82	Crotch 22.82 feet above ▲.
Spear, heliotrope ....ft..		14. 3	10. 4	1. 42	Heliotrope, 11.33 feet above △.
Smith, ground	....	12. 3	12. 8	0. 38	
S.W. Peak, rock ....v. unst..	....	13. 2	11. 8	2. 14	
Cahas, ground ....v. ft..	....	13. 2	11. 8	14. 03	
Buffalo, top of trees......... ......v. ft..	....	13. 3	11. 7	12. 08	Secondary objects. Tops 30 feet above ground.
Sugarloaf, top of trees ....dst..	....	13. 3	11. 8	3. 92	Do.
Tobacco Row, crotch.............v. unst..	0 45 p. m.	13. 7	11. 3	6. 83	Weather clear. Wind light, S.W. Bar. 26.82 in. Ther. 72°.7 F. Telescope above ground, △ 5.99 feet.
SERIES V.					
Etc., etc.					

Reciprocal zenith distances measured at any two stations at the same moment of time, or under the same supposed condition of the atmosphere, give the best results. When reciprocal, but not simultaneous, the observations should be made on different days, as in the case of horizontal angles, in order to obtain, as far as possible, a mean value of the difference between the respective angles and an average value of the refraction. The same care should be taken when the zenith distance is measured at one station only.

Experience has proved that the refraction is greater and more variable at sunrise than at any other hour of the day; that it gradually diminishes, in both respects, until 9 or 10 a. m.; that between those hours and 3½ p. m. it is comparatively stationary, and from 3½ p. m. to sunset it increases in amount and variation, being the greatest during the night. The best period for observing, therefore, is between 9 a. m. and 3½ p. m., and the worst at sunrise and sunset.

The condition of the atmosphere and the relative refraction may be so different at stations situated more than twenty miles apart, that, as a general rule, the difference of level determined even by reciprocal observations cannot be relied upon for the desired degree of accuracy at distances greater than about twenty miles, unless a very large number of measurements have been made under the most favorable circumstances. The higher the elevations the more reliable the results.

When a station is occupied for vertical observations, the zenith distance of every signal in sight should be measured, so as to have more than one check for each altitude. A number of such measures and differences of level should be so combined, by the method of least squares, as to give the most probable values for the respective altitudes, as well as for the coefficient of refraction for the period of observation.

I.—*By reciprocal zenith distances, simultaneous or not.*

Let Z, Z' = the measured zenith distances of the telescopes at the two stations.
K = distance, in metres, between the two stations.
R = radius of curvature of the arc joining the two stations.
C = angle at the earth's centre, subtended by the arc.
h, h' = heights of the two stations above mean tide.

$$C = \frac{K}{R \sin 1''} \qquad\qquad h - h' = \frac{K \sin \frac{1}{2}(Z' - Z)}{\cos \frac{1}{2}(Z' - Z + C)}$$

The value of R, or of $\frac{1}{R \sin 1''}$ (which depends on the mean latitude of the two stations and the angle made by the arc with the meridian), may be computed for different latitudes, and for angles varying from 0° to 90° as in the following table, based upon Clarke's constants.

Table of logarithms of radius of curvature.

	Azimuth.	LATITUDE. 24°	26°	28°	30°	32°	34°	36°
Meridian	° 0	6.802479	6.802597	6.802722	6.802852	6.802988	6.803129	6.803274
	5	2498	2615	2739	2869	3004	3145	3289
	10	2553	2669	2791	2919	3052	3190	3332
	15	2644	2756	2875	3000	3130	3265	3404
	20	2766	2875	2990	3111	3236	3366	3500
	30	3093	3192	3298	3405	3518	3636	3757
	40	3496	3580	3671	3766	3864	3967	4072
	50	3923	3994	4070	4150	4233	4319	4407
	60	4325	4384	4446	4512	4580	4650	4723
	70	4653	4702	4753	4807	4863	4921	4980
	75	4776	4822	4869	4918	4969	5022	5076
	80	4867	4909	4953	4999	5047	5097	5148
	85	4923	4963	5006	5049	5096	5143	5192
Perpendicular.	90	6.804942	6.804981	6.805023	6.805066	6.805112	6.805159	6.805207
		38°	40°	42°	44°	46°	48°	50°
Meridian	0	6.803422	6.803573	6.803726	6.803880	6.804035	6.804189	6.804342
	5	3436	3586	3739	3892	4045	4199	4351
	10	3478	3626	3775	3926	4077	4228	4378
	15	3546	3690	3835	3982	4130	4277	4423
	20	3637	3776	3917	4059	4201	4343	4484
	30	3880	4006	4133	4262	4391	4519	4647
	40	4179	4289	4400	4511	4623	4735	4846
	50	4498	4590	4683	4777	4871	4965	5058
	60	4797	4873	4949	5025	5104	5181	5257
	70	5041	5104	5166	5229	5293	5357	5420
	75	5133	5190	5248	5307	5364	5423	5481
	80	5201	5254	5308	5363	5417	5472	5526
	85	5242	5294	5345	5397	5450	5502	5564
Perpendicular.	90	6.805256	6.805307	6.805358	6.805409	6.805460	6.805512	6.805563

For a more extended table, see Appendix 18, 1876.

Example.

$K = 23931^m.6$ ...... distance between two stations, Santa Cruz and Mount Bache, California.
$Z = 87° 35' 01''.06$ .. observed at Santa Cruz station, reduced to ground at Mount Bache.
$Z' = 92° 35' 34''.20$ .. observed at Mount Bache, reduced to ground at Santa Cruz station.
$L = 37° 02'$ ...... mean latitude of the two stations.
angle $= 51° 55'$ .... angle made by line with the meridian.

Computation of h—h'.

			° ′ ″		
log K	4.3790	$Z'-Z$	5 00 33.14	log K	4.3790
co. log R sin 1″ ..	8.5101	$\frac{1}{2}(Z'-Z)$ ...	2 30 16.57	log sin $\frac{1}{2}(Z'-Z)$.	8.6405
		$Z'-Z+C$	5 13 28.06	co. log cos $\frac{1}{2}(Z'-Z+C)$.	0.0004
log C	2.8891	$\frac{1}{2}(Z'-Z+C)$.	2 36 44.03		
C =	774.56				3.0199

	m
Difference in height	1046.90
Santa Cruz station above mean tide—by spirit-level	108.87
Mount Bache above mean tide	1155.77

II.—*By the zenith distance measured at one station.*

Let Z = the measured zenith distance of the signal or object.
K = the distance between the two stations, in metres.
m = the coefficient of refraction.

$$C = \frac{K}{R \sin 1''}$$

dh = difference in height between the two stations.

$$dh = \frac{K \cos (Z + mC - \frac{1}{2}C)}{\sin (Z + mC - C)}$$

Example.

$Z = 87^\circ\ 07'\ 18''.8$ .... observed at Farmington upon crotch at Mount Blue.
$K = 15519^m$ .... distance between Farmington and Mount Blue.
$m = 0.071$ .... coefficient of refraction.
$L = 44^\circ\ 42'$ .... mean latitude of the two stations.
angle $= 65^\circ\ 44'$ .... angle made by line with meridian.
Telescope above ground $= 2^m.2$. Crotch above ground $= 4^m.4$.

					$^\circ\ '\ ''$		
log K	4.1907	C	$501''.2$	$Z + mC$	87 07 54.4	log K	4.19086
table	8.5093	m	$0''.071$	$Z + mC - \frac{1}{2}C$ ...	87 03 43.8	log cos	8.70971
		mC	$35''.6$	$Z + mC - C$	86 59 33.2	co. log sin ..	0.00060
log C	2.7000						2.90117

	m
dh—between telescope and crotch	796.47
Telescope above ground	+2.20
Crotch above ground	—4.40
dh—between ground at Farmington and Mount Blue	794.27
Ground at Farmington above mean tide	181.20
Ground at Mount Blue above mean tide	975.47

III.—*By the observed zenith distance of the sea horizon.*

Z = the measured zenith distance.
R = radius of curvature of arc.
m = coefficient of refraction $= 0.078$.

$$h = \frac{R}{2(1-m)^2} \tan^2 (Z - 90^\circ)$$

Example.

$Z = 90^\circ\ 24'\ 19''.1$ — Telescope above ground .... $1^m.67$
$L = 41^\circ\ 15'$ — State of tide—below half-tide. 0.30
angle $= 15^\circ$
R = 6.8038 from table.

$(1-m) = (1-0.078) = 0.922$ log $(0.922)^2$ 9.92946
log 2 .... 0.30103

log 2 $(1-m)^2$ .. 0.23049 — log R 6.8038
.... 0.2305

$\log \frac{R}{2(1-m)^2}$ 6.5733

$(Z - 90^\circ) = 24'\ 19''$ log tang^2 $(24'\ 19'')$ 5.6994

2.2727

	m
Diff. of height between telescope and sea horizon........	187.37
Telescope above ground.........	—1.67
Reduction for state of tide..................	—0.30
Height of station above mean tide.....................	185.40

IV.—*By observed angles of elevation or depression.*

A = the observed angle, expressed in seconds.
K = the distance, in metres, between the two stations.
constant = 0.00000485 log constant = 4.68574.
constant = 0.0000000667 log constant = 2.82413.
$d\,h = 0.00000485\ \mathrm{K\,A} + 0.0000000667\ \mathrm{K}^2.$

This formula gives the difference in height between stations not more than ten or fifteen miles apart, with a probable error less than the uncertainty in the co-efficient of refraction.

Example.

$\mathrm{A} = 2^\circ\ 52'\ 41''.2 = 10361''.2$ = angle of elevation.
$\mathrm{K} = 15519^{\mathrm{m}}$ = distance between the two stations.

		m			m
log A...	4.01541				
log K............	4.19086		log K²............	8.38172	
log constant... ..	4.68574		log constant......	2.82413	
	2.89201....	779.85		1.20585...	16.06
		16.06			
	$d\,h$ =	795.91			

THE CO-EFFICIENT OF REFRACTION.

The co-efficient of refraction, or proportion of the intercepted arc, is determined from the observed zenith distances of two stations, the relative altitudes of which have been determined by the spirit-level; or, from reciprocal zenith distances simultaneous or not, under the assumption that the mean of a number of observations taken under favorable conditions will eliminate the difference of refraction which is found to exist, even at the same moment, at two stations a few miles apart. Such a co-efficient may be established for the level of the sea, or for high elevations, or for lines over water or over land. As, however, the difference of height, deduced from trigonometrical leveling, depends upon the co-efficient multiplied by the square of the distance, it is evident that the longer the line the greater would be the error caused by any uncertainty in the co-efficient or actual refraction, and that, consequently, there is a limit to the distance for which any assumed mean value of the refraction can be depended on for accurate results.

The average value of the co-efficient from the Coast Survey observations is,

across parts of the sea near the coast..............	0.078
between primary stations..................	0.071
in the interior of the country, about............. .	0.065

To determine the co-efficient of refraction from reciprocal zenith distances.

C = angle at earth's centre subtended by arc.
F = angle of refraction.
m = co-efficient of refraction.

$$\mathrm{C} = \frac{\mathrm{K}}{\mathrm{R}\sin 1''} \qquad \mathrm{F} = \frac{\mathrm{C}}{2} - \tfrac{1}{2}(\mathrm{Z}' + \mathrm{Z} - 180^\circ) \qquad m = \frac{\mathrm{F}}{\mathrm{C}}$$

Example.

Adopting the observations and corrections in the example to I, and leaving out, as in that case, the very small corrections depending on the height of the stations above the mean surface of the sphere, we have,

	′ ″		″	log's.
$Z+Z'-180°$	10 35.26		$F=69.7$	1.8432328
$\frac{1}{2}(Z+Z'-180°)$	5 17.63		$C=774.66$	2.8891111
$\frac{C}{2}$	6 27.33			
			$m=0.089975$	8.9541217
F	1 09.70			

To determine the co-efficient from the zenith distance observed at one station, when the altitudes of the two stations above half-tide, or their difference in height, have been determined by the leveling-instrument.

Compute the true zenith distances Z'_o and Z_o, of the two given points, and the difference between the true and the observed zenith distance will be the angle of refraction, F; and $m=\frac{F}{C}$

$$\tfrac{1}{2}(Z'_o+Z_o)=90°+\frac{C}{2}$$

$$\tfrac{1}{2}(Z'_o-Z_o)=\tan^{-1}\left(\frac{h'-h}{K}\left\{1-\frac{h'+h}{2R}\pm\frac{K^2}{12R^2}\right\}\right)$$

Example.

Adopting the data afforded by the example to II, we have,

$h'+h=975^m.47$, supposed to be determined by leveling-instrument.

$h'-h=794^m.27$, supposed to be determined by leveling-instrument.

Z=observed Z. D.+correction for height of crotch above telescope.

$Z=87°\ 07'\ 18''.8+29''.2=87°\ 07'\ 48''$.

$K=15519^m$ $\log K=4.1908637$

$C=501''.2=8'\ 21''.2$; and $\frac{C}{2}=4'\ 10''.6$

$\log R^2=3.6102$ $\log K^2=8.3817$
$\log 12=1.0792$ $\log 12R^2=4.6894$

4.6894 3.6923 −0.00000049

$\log R=6.8051$ $\log h'+h=2.9892$
$\log 2=0.3010$ $\log 2R=7.1061$

7.1061 5.8831 −0.00007641

−0.00007690
0.99992310

$\log h'-h=2.8999682$
$\log K=4.1908637$

$\log\frac{h'-h}{K}=8.7091045$

$\log 0.99992310=9.9999666$ $\log\left(1-\frac{h'+h}{2R}-\frac{K^2}{12R^2}\right)=9.9999666$

$\log\tan=8.7090711$
$2°\ 55'\ 46''.7$

	° ′ ″	° ′ ″
$\frac{1}{2}(Z'_o+Z_o)$	=90+4 10.6	=90 04 10.6
$\frac{1}{2}(Z'_o-Z_o)$		= 2 55 46.7
true Z'_o		=92 59 57.3
true Z_o		=87 08 23.9
observed Z		=87 07 48.0

F=	35.9	$\log F=1.5550944$
C=	501.2	$\log C=2.7000111$
$m=\frac{F}{C}$	=0.0716	$\log m=8.8550833$

THE THREE-POINT PROBLEM.

If three points, forming a triangle of which the sides and angles are known, or can be computed, be visible from a fourth point, P, it is required to determine the position of P.

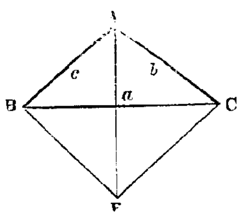
Set up the theodolite at P, and measure the two angles subtended by any two of the given sides.

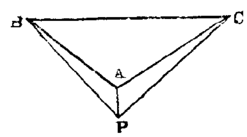
This problem is of use in cases where the regular triangulation having been completed, additional points are required for the topographical survey, or are needed for special service. The angles should be carefully measured, and in the computations the logarithms should be carried to seven places of decimals.

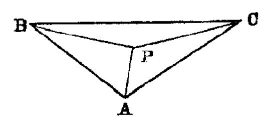
Three cases of its application are given, as in others, such as when P falls upon one or the other of the sides of the known triangle, or on the prolongation of either, the case resolves itself into the solution of a simple triangle with one side and the angles given; or the problem is indeterminate, as when P is situated on the circumference of the circle passing through the three known points—a contingency which rarely occurs.

Example for each of the three cases.

Given the side	$a=11204.5$	Angle observed	A P C=P′
Given the side	$b=$ 7289.0	Angle observed	A P B=P″
Given the side	$c=$ 6273.8	To find	A B P=x
Given the angle	A=111° 10′ 54″	To find	A C P=y







P′	50° 06′ 12″	P′	49° 47′ 20″	P′	104° 00′ 00″
P″	43° 50′ 38″	P″	44° 09′ 30″	P″	100° 20′ 00″
S	180°$-\frac{1}{2}$(A+P′+P″)	S	$\frac{1}{2}$(A−P′−P″)	S	180°$-\frac{1}{2}$(A+P′+P″)
S	77° 26′ 08″	S	8° 37′ 02″	S	22° 14′ 33″

$$\tan Z=\frac{c \sin P'}{b \sin P''} \qquad \varepsilon=\tfrac{1}{2}(x-y) \qquad \tan \varepsilon=\cot (Z+45°) \tan S$$

$x=S+\varepsilon$ $\quad y=S-\varepsilon$, but if $\tan \varepsilon$ be negative, then $x=S-\varepsilon$, $\quad y=S+\varepsilon$

Computation.

log c	3.7975307	log c	3.7975397	log c	3.7975307
log sin P′	9.8849100	log sin P′	9.8829061	log sin P′	9.9869041
co. log b	6.1373320	co. log. b	6.1373320	co. log b	6.1373320
log co. sin P″	0.1594574	log co. sin P″	0.1569894	log co. sin P″	0.0071016
log tan Z	9.9792301	log tan Z	9.9747583	log tan Z	9.9288684
Z	43° 37′ 49″.6	Z	43° 20′ 09″.2	Z	40° 19′ 43″.3
log cot (Z+45°)	8.3785397	log cot (Z+45°)	8.4631818	log cot (Z+45°)	8.9122794
log tan S	0.6519386	log tan S	9.1805366	log tan S	9.6116787
log tan ε	9.0304783	log tan ε	7.6437184	log tan ε	8.5239581
ε	6° 07′ 21″.7	ε	0° 15′ 08″.1	ε	1° 54′ 50″.04
S	77° 26′ 08″.0	S	8° 37′ 02″.0	S	22° 14′ 33″.00
x	83° 33′ 29″.7	x	8° 52′ 10″.1	x	24° 09′ 23″.00
y	71° 18′ 46″.3	y	8° 21′ 53″.9	y	20° 19′ 43″.00
Hence,		Hence,		Hence,	
P A B	52° 35′ 52″.3	P A B	126° 58′ 19″.9	P A B	55° 30′ 37″.00
P A C	58° 35′ 01″.7	P A C	121° 50′ 46″.1	P A C	55° 40′ 17″.00

As all the angles and a side in each triangle are now known, the other sides, or the distances from P to the three given points, can be readily computed.

	m		m		m
P B	7194.87	P B	7194.94	P B	5256.29
P A	8999.89	P A	1388.54	P A	2609.75
P C	8107.98	P C	8107.91	P C	6203.63
P A	8999.89	P A	1388.54	P A	2609.75

The results are verified when both triangles give the same value for the line P A.

For the problem and an example by C. A. Schott, of determining a position by angles observed upon a number of given stations, see page 116, Coast Survey Report, 1864.

RECTANGULAR CO-ORDINATES ON A PLANE PROJECTION.

The method of plotting the position of trigonometrical points by rectangular co-ordinates is occasionally adopted in the field, and consists in referring the points of the triangulation to two straight lines, intersecting each other at right angles, called the co-ordinate axes. If O be the point of intersection, or origin of the axes, then y will be the axis of ordinates, x the axis of abscissæ, and Aa, Oa, or y, x, the rectangular co-ordinates of a given point A.

Should the true meridian be known, let that be the axis of ordinates, and the point of intersection a trigonometrical point; if not known, adopt as the axis of abscissæ, a side of one of the triangles, which, if extended in one or both directions, would pass through the center of the triangulation, or as near thereto as possible. The triangulation point at one or the other end of this line, as may be preferred, will be, therefore, the origin of ordinates. Whatever may be the direction of the line, assume it for the present purpose to be a meridian, and count the azimuths from south to west as in the L, M, Z computations.

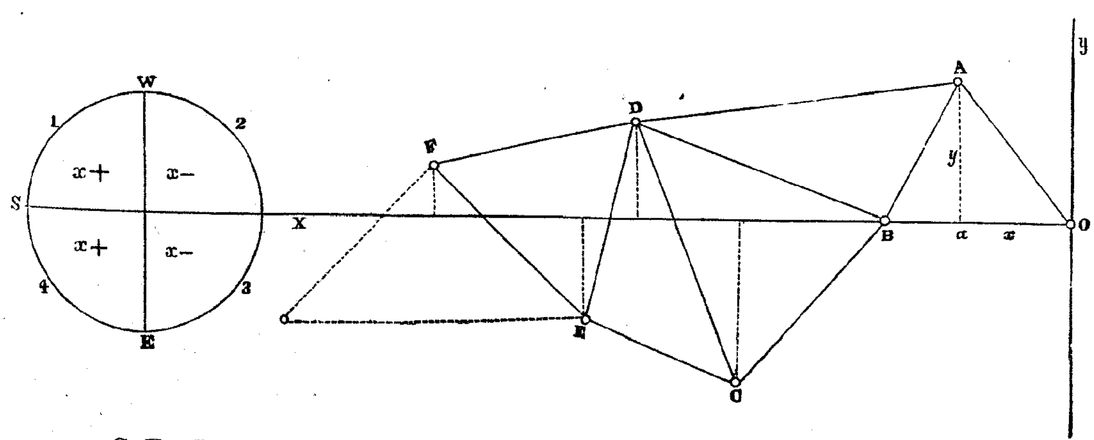
The values of the rectangular co-ordinates y and x, are obtained by multiplying the triangle side by the sine and cosine of its azimuth.

The abscissa, x, will be additive when the azimuth is in the first and fourth quadrants, and subtractive when in the second and third.

The computed ordinate y will be subtractive from or additive to the last ordinate, according as the azimuth converges to or diverges from the axis of abscissæ.

If the ordinates on one side of the axis of abscissæ be regarded as positive, those on the other side will be negative.

Should the line adopted pass through the chain of triangles, as in the following example, having trigonometrical points on both sides, compute the rectangular co-ordinates for the points on one side, and then for those on the other, and the computation will be verified when the sum of the abscissæ, on reaching the terminal point, shall be the same by both series.



	Denomination.	Plane angles and distances.	Logarithms.		Denomination.	Plane angles and distances	Logarithms.
	O to B	5073m.68	3. 7053 34		D to C		3. 8889246
A	Three Sisters	65° 27′ 55″.3	0. 0410968	E	Persimmon Point	99° 38 59″.1	0. 0061888
O	North End	51° 30′ 37″.9	9. 8936078	D	South Base	36° 00′ 15″.2	9. 7692627
B	Ragged Island	63° 01′ 26″.8	9. 9499740	C	Caffee's Point	44° 20′ 45″.7	9. 8444710
	A to B	4365m.44	3. 6400280		E to C	4617m.17	3. 6643761
	A to O	4970m.43	3. 6963042		E to D	5490m.15	3. 7395844
	A to B		3. 6400280		D to E		3. 7395844
D	South Base	28° 29′ 34″ 2	0. 3214372	F	North Base	53° 57′ 19″.6	0. 0922879
A	Three Sisters	53° 19′ 39″.9	9. 9042095	D	South Base	64° 48′ 09″.9	9. 9565754
B	Ragged Island	98° 10′ 45″.9	9. 9955595	E	Persimmon Point	61° 14′ 30″.5	9. 9428302
	D to B	7339m.64	9. 8656747		F to E	6143m.95	3. 7884477
	D to A	7194m.90	3. 9570247		F to D	5252m.54	3. 7747025
	D to B		3. 8656747				
C	Caffee's Point	62° 21′ 23″.7	9. 0526387				
D	South Base	48° 29′ 05″.4	9. 8743544				
B	Ragged Island	69° 09′ 30″.9	9. 9706112				
	C to B	6203m.94	3. 7926678				
	C to D	7743m.27	3. 8889246				

	° ′ ″		
Z O to B	00 00 00.0		
∠ B & A	51 30 37.9		log's.
Z O to A	51 30 37.9	sin	9.8936078
		D	3.6963942
		cos	9.7940492
y	*x*		
+3890.47	3093.45		3.5900020
A			3.4904434

	° ′ ″		
Z B to O	180 00 00.0		
∠ O & A	63 01 26.8		
∠ A & D	98 10 45.9		
∠ D & C	69 09 30.9		
	50 21 43.6		log's.
Z B to C	309 38 16.4	sin	9.8865424
		D	3.7926678
		cos	9.8047694
y	*x*		
0000.00	5073.68		3.6792102
−4777.60	3957.65		3.5974372
−4777.60	9031.33		
C			

	° ′ ″		
Z A to O	231 30 37.9		
∠ O & B	65 27 55.3		
∠ B & D	53 19 39.9		log's.
Z A to D	350 18 13.1	sin	9.2264111
		D	3.9570247
		cos	9.9937510
y	*x*		
+3890.47	3093.45		3.1834358
−1525.58	8928.44		3.9507757
+2364.89	12021.89		
D			

	° ′ ″		
Z C to B	129 38 16.4+		
∠ B & D	62 21 23.7−		
∠ D & E	44 20 45.7−		log's.
Z C to E	22 56 07.0	sin	9.5907205
		D	3.6643761
		cos	9.9642340
y	*x*		
−4777.60	9031.33		3.2550966
−1799.27	4252.16		3.6286101
−2978.33	13283.49		
E			

	° ′ ″		
Z D to A	170 18 13.1		
∠ A & B	28 29 34.2		
∠ B & C	48 29 05.4		
∠ C & E	36 00 15.2		
∠ E & F	64 48 09.9		log's.
Z D to F	348 05 17.8	sin	9.3147189
		D	3.7747025
		cos	9.9905460
y	*x*		
+2364.89	12021.89		3.0894214
−1228.63	5834.36		3.7652485
+1136.26	17846.25		
F			

	° ′ ″		
Z E to C	202 56 07.0+		
∠ C & D	99 38 59.1−		
∠ D & F	61 14 30.5−		log's.
Z E to F	42 02 37.4	sin	9.8258767
		D	3.7884477
		cos	9.8707748
y	*x*		
−2978.33	13283.49		3.6143244
+4114.57	4562.71		3.6592225
+1136.24	17846.20		
F			

&c. &c. &c. &c.

MEASUREMENT OF SUBSIDIARY BASE-LINES.

The Coast Survey annual report for 1854 contains a full description of the compensating base apparatus employed in the measurement of the primary bases on the Atlantic Coast, and the report for 1857, a general description of the sliding-contact apparatus for subsidiary or intermediate bases.*

* In 1880-'81, a new primary five-metre compensation base apparatus was constructed on the plans and under the direction of Assistant C. A. Schott, and with it the Yola Base, California, 11 miles in length, has been lately measured.

The intermediate lines are required either as checks upon the series of small triangles extending along the low coasts south of the Delaware, or for the determination of the distance and direction between two places which cannot be connected by triangulation except at very great expense and probable risk of accuracy. In the latter case, a succession of lines and their deviation in direction are measured, and, if the operation is carefully conducted, and the lines on the beach are not less than two miles in length, the results, when compared with distances from the primary bases, will not fail to be satisfactory.

To explain fully the different successive operations connected with the measurement of a subsidiary line, it may be, perhaps, the best plan to present an abstract of the report of the measurements made by the compiler on the Virginia Coast, south of Cape Henry, in 1867.

Base apparatus.—The assistant is referred to the description of the apparatus and the mode of using it as given in the Coast Survey annual report for 1857, with the remark that the defects in the original, as first employed in the third measurement of the English base on Hounslow Heath, in 1784, have been successfully remedied. In addition to those important improvements, the rods employed in 1867 were six metres in length instead of four; the level of the sector was made more delicate, and on each of the forward trestles a roller was placed to facilitate the movement of the bar, forward and back, during its final adjustment.

Length of rods.—A comparison of the two rods with the standard six-metre bar should be made at the office in Washington, both before and after they are used in the field, and, if no accident has occurred to either during the interval, the mean of the two comparisons should be adopted as their respective values.

In deducing the length of rod from comparisons with the standard six-metre bar No. 2, the following data may be employed:

Length of standard bar No. 2 at 32° F	$5^{m}.99998233$
One division of the scale of comparator, $\frac{1}{14630}$ of an inch	$0^{m}.00000174$
Co-efficient of expansion for F. scale	$0^{m}.00000641$
Thermometer attached to standard—too high	$-0°.7$
Thermometers attached to rods ± (in this case correct).	

Comparisons made at the Coast Survey Office, August 10, 1867.

Standard No. 2.		Rod No. 1.		Standard No. 2.		Rod No. 2.	
Therm.	Divisions.	Therm.	Divisions.	Therm.	Divisions.	Therm.	Divisions.
°		°		°		°	
77.3	+21	76.0	−10	75.3	+ 1	74.0	+7
78.0	+15	76.4	+41	76.0	+ 8	74.5	−3
78.5	+18	77.0	+55	77.0	+13	75.0 } 74°.83	+3 } +1
77.93	+18	76.47	+28.67	76.1	+ 7.33	75.0	+3
− 0.70		77.23	+18.00	− 0.7		74.41	+4.00
77.23		+.76	+10.67	75.4		75.40	+7.33
						+ 0.99	−3.33

Computation of length of rod No. 1.

	m
$+ 0°.76 \times 0.00000641 \times 6^{m}$	+0.00002923
$+ 10^{d}.67 \times 0.00000174$	+0.00001857
at 77°.23, No. 1, longer than st'd..	+0.00004780
at 77°.23, standard No. 2........	6.00172188
at 77°.23, rod No. 1.............	6.00176968
at 75°.00, rod No. 1..	6.00168391

Computation of length of rod No. 2.

	m
$+0°.99 \times 0.00000641 \times 6^{m}$	+0.00003808
$-3^{d}.33 \times 0.00000174$.......	−0.00000579
at 75°.4, No. 2, longer than st'd..	+0.00003229
at 75°.4, standard No. 2........	6.00165149
at 75°.4, rod No. 2........	6.00168378
at 75°.0, rod No. 2	6.00166840

Similar comparisons were made in the month of November following, after the return of the apparatus from the field.

	Rod No. 1.	Rod No. 2.
August 10, 1867, length at 75° F..................	$6^{m}.00168391$	$6^{m}.00166840$
November 21, 1867, length at 75° F................	$6^{m}.00168692$	$6^{m}.00154393$
Mean adopted for the measurement	$6^{m}.00168541$	$6^{m}.00160616$

Instruments, &c., and organization of party.—There will be required one 12-inch theodolite, two small transits, a leveling instrument, telescope, 20-metre chain, metre-scale and extension dividers, a coil of iron wire, one-eighth of an inch in diameter and 70 metres in length, and a spring balance.

One assistant, to make the contact, give the signals, &c.

One aid, to align the bars, using a transit.

One aid, to record the inclination, temperature, and number of the bar, and, when the measurement halts or stops for the day, to transfer the end of rod to copper tack in stub, employing, for this purpose, the other transit.

Two men, to carry the bar.

Two men, to pick up the trestles, carry them forward, adjust them in line, and level them.

One man, to attend the aid in charge of alignment, bring up instrument, &c.

One man, to keep up the transfer transit, and to be provided with stub, axe, and copper tack for an emergency, and to assist generally.

Cart, horse, and driver, for the transportation of heavy wooden box, in which the bars are kept when not in use; of water, stubs, spades, and tools, and of tent, in case of sudden storm.

The record book.—The record book is ruled and kept as in the following specimen pages, except that the remarks are applicable to the day's work, not to the particular number of bars. The left-hand page contains 20 bars or 120 metres, and, as the stubs of the preliminary measurement are driven at every 120 metres, the last number on each page should be an even number, and should coincide with a stub, in order that an error in counting or numbering the bars, cannot be carried beyond the page. The thermometers, one for each rod, are read, and the temperature recorded for every ten bars, and oftener, if any unusual delay occurs, and always when the measurement stops, from any cause, whatever may be the number of the last bar. The inclinations are recorded for each rod, and the columns for the mean temperature and corrections for inclinations are filled up, as the opportunity may offer.

Measurement of the coast. September 22, 1867. VIRGINIA—SECTION IV.						Station B to station C. Clear. Wind, L., westerly.		
Time.	Whole number.	No. of Bar.	Temp.	Inclination. +	Inclination. −	Mean temperatures.	Correction for inclination.	Remarks.
h. m.			°	′	′	°		
11 25	161	1	77.5	42			.000448	Stopped for aligning transit to advance.
	162	2	77.5		17		0074	
	163	1			20		0102	
	164	2		7		76.875×10	0012	
	165	1		1.23		768.75	1749	
	166	2		21			0112	
	167	1			48		0585	
	168	2			3		0002	
	169	1	76.5		5		0006	
11 41	170	2	76.0		19		0092	Stopped. Stub, copper tack, and cross-lines.
12 43	171	1	74.5	13			0043	
	172	2	74.5	9			0021	
	173	1			20		0102	
	174	2		19		74.25×10	0092	
	175	1		56		742.50	0796	
	176	2			37		0348	
	177	1			19		0092	
	178	2			57		0825	
	179	1	74.0	26			0172	
12 56	180	2	74.0		14		0050	Stopped for the day. Stub, copper tack, and cross-lines.
							.005723	

Preparation of the line.—The locality of the proposed base having been selected, either on the beach, adjoining sand plain, or hard land in the interior, the line is traced and its direction adjusted to the least uneven ground and to avoid the tide, dunes, or hillocks, and then cleared of all minor obstructions.

Monuments.—After the line has been finally laid out, the monuments are erected. These may be merely the underground permanent marks, brought up level with the surface of the ground, and the terminus of the line marked thereon, the cap or upper block being reserved until the horizontal angles have been observed. The operation of ending the measurement at a given point is less liable to error and more economical of labor than the process of putting in a temporary mark, and then superseding it by a final one at some time after the measurement has been completed.

Alignment.—The base is aligned by setting up straight poles, prepared for the purpose, at about every half mile. This may be done by adjusting the transit over the mark at one end, fixing the cross-hairs on the signal at the other terminus, and by a system of signals to the aid, who is provided with a telescope, putting the poles in line, working in the direction of the instrument.

During the measurement, an aid, with his transit is stationed in the rear, never more than about one-fourth of a mile from the apparatus, and directs the alignment of the bars by movements of his arm. A small wand about the size of a lead-pencil, and painted black, is firmly fixed in a vertical position at the forward end of each bar, directly over the rod, and when the bar has been approximately brought into position by the men who have it in charge, a signal is made and the aid perfects the alignment.

Adjustment of the apparatus.—Before commencing the measurement, each bar is appropriately arranged upon trestles, and the knife-edge at one end and the center of the plane at the other are brought to the same level, by means of a leveling instrument placed about 20 metres from each end. The rod being level, the level and zero of the sector are adjusted to this condition of the rod. The same operation is gone through with after the measurement is completed, to ascertain if the relation between the sector and the rod has changed, or, in other words, if the readings of the sector have truly expressed the inclination of the rod; and if not, the error. Half of this index-error is the correction to be applied to the recorded inclinations, though, if it is small, as in the following case, and the angles of elevation and depression are about equal in number and value, the error is not appreciable:

	Rod 1, index-error.	Rod 2, index-error.
Before measuring—Station A, adjustment...........	0′.0	0′.0
After measurement—Station B, compared....	+1′.0	0′.0

Hence, for every + inclination recorded for rod No. 1, a correction of 0′.5 should be subtracted, and the same added to each − inclination. The sector of rod No. 2 had remained unchanged.

Preliminary measurement.—The preliminary measurement is made with an iron wire, about one-eighth of an inch in diameter, and 60 metres in length. This distance (10 bars) is measured off with the base apparatus, starting from the initial point, should the ground be favorable, and extending in the direction of the base-line. The terminus is marked by cross-lines drawn on the head of a copper tank driven in a stub sunk level with the surface of the ground. The inclinations and temperatures are recorded, in order that the exact distance may be computed. The wire, which has been previously uncoiled, straightened, and otherwise prepared, and also provided with a loop at each extremity, is then stretched between the two marks by a chain staff at the after end, and a weight of forty pounds applied to the other by means of a spring balance. In this condition, and after repeated trials, the measured distance is transferred to and marked on the wire by a fine line cut near each loop.

The wire is then drawn forward, stretched in line, the uniform weight of forty pounds applied, and at a given signal from the aid in charge of the after end, indicating the adjustment of the wire mark to the stub mark, the forward mark is transferred, by a pencil, to the planed surface of a small wooden bench, sunk nearly level with the ground. The penciled line is then numbered, the wire carried forward, aligned and stretched as before, the after mark adjusted to line on bench, the forward mark transferred to another and similar bench, and so on to the terminus.

The bench, which is about one foot square, and provided with four short legs, is firmly planted in the ground by the pressure of the foot after the wire has been approximately adjusted for direction and distance. Four or five of these benches will be required, one being always left a wire behind as a precaution against accident. Stubs are driven at every second wire, or 120 metres apart, to serve as tests of correctness in counting the bars during the final measurement. Each page of the record will commence and end at one of these stubs.

The end of the last wire, before reaching the terminus, should be marked by cross-lines on the usual copper tack and stub, so that when the final measurement reaches the mark a close comparison may be instituted, if desired, between the two measurements. As the last wire will either fall short of or go beyond the monument, the difference should be measured with the 20-metre chain, a tape-line, or metre scale, according to the distance, and duly recorded with its appropriate sign.

The above operation requires very little more time than the ordinary chain-measurement, and is much more satisfactory. In order to show the accuracy with which such rapid measurements may be made on level ground, the two following comparisons are presented:

	m
By wire measurement. A to B=82 wires × 6^m.00164579 × 10	4921.3495
By base apparatus. A to B=802 bars × 6^m.00164579 − [excess=0^m.019] + [Rudie Creek =107^m.8408]+[temp.=0^m.2107]−[inclination=0^m.1681]	4921.1843
By wire. B to C=71 wires × 6^m.00164579 × 10	4261.1685
By apparatus. B to C=710 bars × 6^m.00164579+[deficiency=0^m.1016]+[temp.=0^m.2200] −[inclination=0^m.1676]	4261.3225

The temperature of rods.—The thermometers attached to the apparatus are compared with the standard at the office, and the correction to be applied, if any, is marked on the scale. The temperature as a rule, is read at every ten bars, and without withdrawing the thermometer from its position next to the rod. Every possible care should be taken to preserve an even or slowly changing temperature, and that the thermometer should express the temperature of the rod. The box in which the bars are deposited at the close of the day's work should be left in an east and west direction, so that one rod or one thermometer may not be found the next morning unduly heated by having been exposed to the morning sun; and should any great difference be noted between the two thermometers, a delay of half an hour is advisable to permit them to settle down to about the same degree. The measurement should stop when the temperature is over 100°.

Inclination of the rods.—The bars, for obvious reasons, should not be allowed to rest for any length of time on the trestles; and as rapidity in the measurement is in some degree essential to its success, no time should be lost during the operation in an attempt to keep the bars exactly level. The inclination should be observed while the assistant is perfecting the contact, and the correction therefor will answer every purpose. When the inclination exceeds 3° or 4°, or is beyond the range of the sector, a vertical offset becomes necessary. The transit is set up directly opposite to the end last adjusted, and very carefully leveled. The after-bar is then carried forward, placed on its trestles, leveled, and aligned, and then moved backward or forward, as the case may require, approximately by hand and finally by the slow-motion screw, until the knife-edge, adjusted for coincidence of line, is brought in the vertical of the plane of the fixed rod, under the direction of the aid in charge of the transit. When the contour of the ground shows that a vertical offset is unavoidable, the last bar shall be made as level as possible. Care should be taken, however, when approaching an elevation or depression in the ground, so to manage the inclination of the bars as to avoid or to have as few as possible of such offsets. A table containing the correction for each minute of inclination may be computed by the following formula:

R = length of rod .... say 6^m.00164579
θ = inclination in minutes .... say 25′

correction $= \frac{\sin^2 1'}{2} \theta^2$ R constant $= \frac{\sin^2 1'}{2}$ log constant 2. 626422

log constant	2. 626422	
log θ^2	2. 795880	
log R	0. 778270	
	6. 200572	0^m.00015870

Table of corrections for inclination for four-meter bars.

[Correction for inclination = versed sine × 4.]

° ′		° ′		° ′		° ′		° ′	
0 00	0.00000	1 00	0.00061	2 00	0.00244	3 00	0.00548	4 00	0.00974
01	00	01	63	01	248	01	554	01	983
02	00	02	65	02	252	02	560	02	991
03	00	03	67	03	256	03	567	03	999
04	00	04	69	04	260	04	573	04	1007
05	00	05	71	05	264	05	579	05	1015
06	01	06	74	06	269	06	585	06	1024
07	01	07	76	07	273	07	592	07	1032
08	01	08	78	08	277	08	598	08	1040
09	01	09	81	09	282	09	604	09	1049
10	02	10	83	10	286	10	611	10	1057
11	02	11	85	11	290	11	617	11	1066
12	02	12	88	12	295	12	624	12	1074
13	03	13	90	13	299	13	630	13	1083
14	03	14	93	14	304	14	637	14	1091
15	04	15	95	15	308	15	643	15	1100
16	04	16	98	16	313	16	650	16	1109
17	05	17	100	17	318	17	657	17	1117
18	05	18	103	18	322	18	663	18	1126
19	06	19	106	19	327	19	670	19	1135
20	07	20	108	20	332	20	677	20	1143
21	07	21	111	21	336	21	684	21	1152
22	08	22	114	22	341	22	690	22	1161
23	09	23	117	23	346	23	697	23	1170
24	10	24	119	24	351	24	704	24	1179
25	11	25	122	25	356	25	711	25	1188
26	11	26	125	26	361	26	718	26	1197
27	12	27	128	27	366	27	725	27	1206
28	13	28	131	28	371	28	732	28	1215
29	14	29	134	29	376	29	739	29	1224
30	15	30	137	30	381	30	746	30	1233
31	16	31	140	31	386	31	753	31	1242
32	17	32	143	32	391	32	760	32	1251
33	18	33	146	33	396	33	768	33	1261
34	20	34	150	34	401	34	775	34	1270
35	21	35	153	35	407	35	782	35	1279
36	22	36	156	36	412	36	789	36	1288
37	23	37	159	37	417	37	797	37	1298
38	24	38	163	38	422	38	804	38	1307
39	26	39	166	39	428	39	811	39	1317
40	27	40	169	40	433	40	819	40	1326
41	28	41	173	41	439	41	826	41	1336
42	30	42	176	42	444	42	834	42	1345
43	31	43	180	43	450	43	841	43	1355
44	33	44	183	44	455	44	849	44	1364
45	34	45	187	45	461	45	856	45	1374
46	36	46	190	46	466	46	864	46	1383
47	37	47	194	47	472	47	872	47	1393
48	39	48	197	48	478	48	879	48	1403
49	41	49	201	49	483	49	887	49	1413
50	42	50	205	50	489	50	895	50	1422
51	44	51	208	51	495	51	903	51	1432
52	46	52	212	52	501	52	911	52	1442
53	48	53	216	53	506	53	918	53	1452
54	49	54	220	54	512	54	926	54	1462
55	51	55	224	55	518	55	934	55	1472
56	53	56	228	56	524	56	942	56	1482
57	55	57	232	57	530	57	950	57	1492
58	57	58	236	58	536	58	958	58	1502
59	59	59	240	59	542	59	966	59	1512
60	61	60	244	60	548	60	974	60	1522

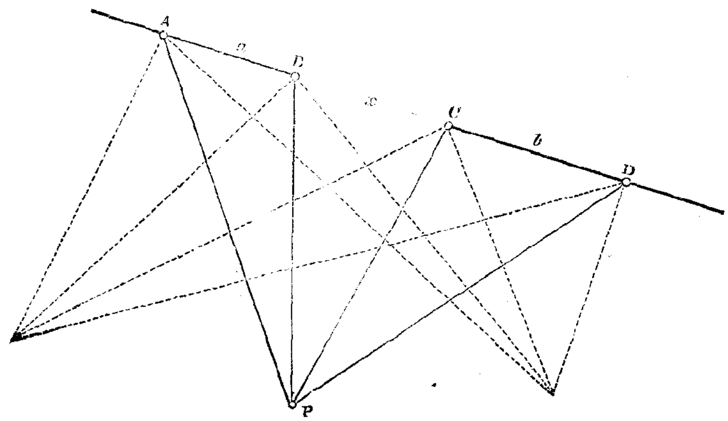
Table of corrections for inclination for six metre bars.

[Correction for inclination = versed sine × 6.]

° ′		° ′		° ′		° ′		° ′	
0 00	0.00000	1 00	0.00091	2 00	0.00366	3 00	0.00822	4 00	0.01462
01	00	01	94	01	372	01	831	01	1474
02	00	02	98	02	378	02	841	02	1486
03	00	03	101	03	384	03	850	03	1498
04	00	04	104	04	390	04	859	04	1511
05	01	05	107	05	397	05	869	05	1523
06	01	06	111	06	403	06	878	06	1536
07	01	07	114	07	409	07	887	07	1548
08	02	08	117	08	416	08	897	08	1561
09	02	09	121	09	422	09	907	09	1573
10	03	10	124	10	429	10	916	10	1586
11	03	11	128	11	436	11	926	11	1599
12	04	12	132	12	442	12	936	12	1611
13	04	13	135	13	449	13	945	13	1624
14	05	14	139	14	456	14	955	14	1637
15	06	15	143	15	463	15	965	15	1650
16	06	16	147	16	469	16	975	16	1663
17	07	17	150	17	476	17	985	17	1676
18	08	18	154	18	483	18	995	18	1689
19	09	19	158	19	490	19	1005	19	1702
20	10	20	162	20	497	20	1015	20	1715
21	11	21	167	21	505	21	1025	21	1728
22	12	22	171	22	512	22	1035	22	1742
23	13	23	175	23	519	23	1046	23	1755
24	15	24	179	24	526	24	1056	24	1768
25	16	25	183	25	534	25	1067	25	1782
26	17	26	188	26	541	26	1077	26	1795
27	18	27	192	27	548	27	1087	27	1809
28	20	28	197	28	556	28	1098	28	1822
29	21	29	201	29	563	29	1109	29	1836
30	23	30	206	30	571	30	1119	30	1850
31	24	31	210	31	579	31	1130	31	1863
32	26	32	215	32	586	32	1141	32	1877
33	28	33	220	33	594	33	1151	33	1891
34	29	34	224	34	602	34	1162	34	1905
35	31	35	229	35	610	35	1173	35	1919
36	33	36	234	36	618	36	1184	36	1933
37	35	37	239	37	626	37	1195	37	1947
38	37	38	244	38	634	38	1206	38	1961
39	39	39	249	39	642	39	1217	39	1975
40	41	40	254	40	650	40	1228	40	1989
41	43	41	259	41	658	41	1239	41	2003
42	45	42	264	42	666	42	1251	42	2018
43	47	43	269	43	674	43	1262	43	2032
44	49	44	275	44	683	44	1273	44	2046
45	51	45	280	45	691	45	1285	45	2061
46	54	46	285	46	699	46	1296	46	2075
47	56	47	291	47	708	47	1308	47	2090
48	59	48	296	48	716	48	1319	48	2104
49	61	49	302	49	725	49	1331	49	2119
50	63	50	307	50	734	50	1342	50	2134
51	66	51	313	51	742	51	1354	51	2148
52	69	52	318	52	751	52	1366	52	2163
53	71	53	324	53	760	53	1378	53	2178
54	74	54	330	54	768	54	1389	54	2193
55	77	55	336	55	777	55	1401	55	2208
56	80	56	342	56	786	56	1413	56	2223
57	83	57	347	57	795	57	1425	57	2238
58	85	58	353	58	804	58	1437	58	2253
59	88	59	359	59	813	59	1449	59	226[illegible]
60	91	60	366	60	822	60	1462	60	2283

The distance across a creek, quicksand, &c.—When it is not possible to obtain the desired length of base-line without crossing a short distance in which the bars cannot be used or it would be unsafe to depend upon them, as in the case of water, quicksand, boggy soil, or even a rapid succession of great irregularities in the ground, the unmeasured distance should be determined by the following method:

Let AB represent a section of the regularly measured base about equal to the distance to be crossed, with its ends carefully marked. Recommence the measurement on the other side of creek or bog, and mark off a longer or shorter distance, CD, all in the line of the base. Set up and adjust the theodolite on firm ground at P and in sight of the stubs at A, B, C, and D. At the intersection of the cross-lines on the tacks at these four points, or in line to P, insert a short wire, or nail, or the smallest object distinctly visible from P. Then measure the angles APD, APC, and APB, and for verification the angle BPD.



Example.—Crossing of Rudie Creek.

Let AB $= a =$ 90^{m}.0242=distance corrected for inclination and temperature.
CD $= b =$120^{m}.0316=distance corrected for inclination and temperature.
BC $= x =$the unmeasured distance.
APB=A^1=19° 41′ 44″.56=mean of observations.
APC=A^2=49° 02′ 29″.77=mean of observations.
APD=A^3=75° 22′ 02″.56=mean of observations.
BPD=A^4=55° 40′ 14″.50=mean of observations.

$$x=-\frac{a+b}{2}\pm\frac{a-b}{2\cos y} \qquad \text{tang}^2\, y=\frac{4ab}{(a-b)^2}\cdot\frac{\sin A^2 \sin (A^3-A^1)}{\sin A^1 \sin (A^3-A^2)}$$

			log's.
$\sin (A^3-A^1)$ =55° 40′ 16″.25			9.9168826
$\sin A^2$=49° 02′ 29″.8			9.8780538
$\sin (A^3-A^2)$ =26° 19′ 32″.8		(arc co)	0.3531314
$\sin A^1$=19° 41′ 44″.6		(arc co)	0.4723380
$a =$ 90^{m}.0242			1.9543593
$b =$120^{m}.0316			2.0792956
4			0.6020600
$(a-b)^2$		(arc co)	7.0455432
$\tan^2 y$			2.3016639
$\tan y$			1.1508319
y	85° 57′ 29″.7		
$(a-b)$			1.4772284
$\cos y$		(arc co)	1.1519135
2		(arc co)	9.6989700
$\frac{a-b}{2\cos y}$			2.3281119

212^{m}.8687

$\frac{a+b}{2}$=105^{m}.0279

x=107^{m}.8408

For verification, change the position of P, and from the new point observe the same angles, and with these recompute x. In the above the unmeasured distance determined from two positions was found to be identical.

Verification of measurement.—Care must be taken, while making the contact, to bring the knife-edge to the center of plane; to hold the magnifying glass parallel with the rod when bringing the line on the index plate and slide to coincide; to make no mistake in reading the thermometer or angle of inclination, and especially in the adjustment of the transit for vertical offsets, or when the end of the rod is to be transferred to a stub.

To test the accuracy of the measurement, a part of the line should be always remeasured, and if there is any doubt, the entire line. The following comparison is copied from the record of the measurement on the Virginia Coast:

August 30, 1867, from bar 148 to bar 286, inclusive,	m	
Mean of rods=$6^m.00164579 \times 138$ bars	828.22711902	
Correction for temperature above 75°	+0.00227743	
Correction for inclination of rods	−0.02329017	m
		828.20610628
September 2, same distance remeasured,		
Mean of rods=$6^m.00164579 \times 138$ bars	828.22711902	
Correction for temperature 75°	+0.02084498	
Correction for inclination of rods	−0.02279271	
Correction for error in alignment of 19 bars	+0.00007717	
Measured excess, at 286th bar	−0.01970000	
		828.20554846
Difference about two-hundredths of an inch		0.00055600

Length of line.—The mean temperature of the rods during the measurement is obtained by multiplying the number of bars (usually, but not always, ten) between the observed temperatures, by the mean of the four temperatures, and by dividing the sum of these quantities by the total number of bars measured. The corrections for inclination are added, and the sum subtracted from the measured distance.

	m
Rod No. 1=$6^m.00168541$ at 75° F.×404 bars	2424.68090564
Rod No. 2=$6^m.00160616$ at 75° F.×404 bars	2424.64888864
Distance across Rudie Creek computed	+107.84080000
Distance beyond 826th bar to centre of station	+ 0.71930000
Mean temperature=81°.77, correction for 6°.77 above 75°	+ 0.21094919
Correction for inclination of rods	− 0.16968103
	4957.93116244

When two lines and the included angle are measured:

Let $a=4957^m.931162$

$b=4307^m.587099$

C=177° 37′ 58″.31, or deviation from straight line=2° 22′ 01″.69

θ=2° 22′ 01″.69, reduced to angle of chords, or 142′.0282

$$\text{correction} = \frac{\sin^2 1'}{2} \cdot \frac{ab\,\theta^2}{a+b}$$

log θ	2.1523746	
log θ	2.1523746	
log a	3.6953005	
log b	3.6342341	
co. log $(a+b)$	6.0331303	
constant=$\frac{\sin^2 1'}{2}$ log constant	2.6264222	
		m
	0.2938363	− 1.967247
		$a+b$=9265.518261
Length of line connecting extreme points		9263.551014

Four lines were measured in the fall of 1867, the maximum deviation in direction being 4° 27′ 06″. The correction to the sum of the measured distances to reduce them to a straight line was $32^m.616$,

	m
And the resulting length of the direct line	14270.931
Reduction to mean level of sea	−0.005
	14270.926

To reduce to level of half-tide,

K = the distance or length of line.
h = mean height of bars above half-tide.
R = radius of curvature of the arc.

$$\text{Correction} = \frac{Kh}{R}$$

$K = 14270^m.926$	log K	4.15445
$h = 2^m.36$	log h	0.37291
R	co. log R	3.19660
correction $= 0^m.005296$		7.72400

At each station the horizon was closed by observing the supplemental angle, and while occupying the initial point, the azimuth of the triangulation was transferred to the terminus of each of the measured lines, as well as to the most distant visible station, to serve as checks and conditions.

RECORDS, DUPLICATES, AND COMPUTATIONS.

Beside the monthly and annual reports to be made to the Superintendent, in conformity with his "General Instructions," the following records, appertaining to the triangulation, are directed to be forwarded to or deposited at the office:

I. A carefully prepared copy of the original observations.
II. A copy of the descriptions of stations.
III. A copy of the plan of the triangulation, the primary on a scale of $\frac{1}{400000}$, the secondary $\frac{1}{100000}$, and the tertiary on a scale of $\frac{1}{40000}$. These plans should show each unobserved angle by the usual broken line for half the length of one or both of the inclosing sides; also the general features of the country embraced within its limits; and, in the tertiary, a sketch of the shore-line.

The above duplicates are generally kept up in the field as the work advances, and are forwarded to the office at the close of the season's operations.

IV. The original volumes containing the observations of horizontal and vertical angles.
V. The original volume, entitled "Descriptions of Stations."
VI. An abstract of the measurements and resulting angles, corrected, if necessary, for phase of signals and eccentricity of stations.
VII. A cahier containing the triangle side computations.
VIII. The L. M. Z. computations.
IX. An abstract of the results for latitude, longitude, and azimuth.
X. An abstract of the results for differences of heights.

These are all forwarded to the office as soon as possible after the assistant has completed his computations. No least square adjustments are required.

NOTE.

As the measurements in the survey of the coast are made and expressed in metres, the following values and logarithms, from the latest comparisons, are given to convert the distances, horizontal and vertical, found in the preceding pages, into inches, feet, yards, and miles:

Metres × 39.370432 = inches, or to log of metres add 1.5951701
Metres × 3.280869 = feet, or to log of metres add 0.5159889
Metres × 1.093623 = yards, or to log of metres add 0.0388676
Metres × 0.000621377 = miles, or to log of metres add 6.7933550

Tables for the conversion of metres into inches and inches into metres.

[1 metre=39.370432 inches. log.=1.5951702.]

Metres.	Inches.
1	39.37043
2	78.74086
3	118.11130
4	157.48173
5	196.85216
6	236.22259
7	275.59302
8	314.96346
9	354.33389

[1 inch=0.02539977 metre. log.=8.4048298.]

Inches.	Metres.
1	0.025400
2	0.050800
3	0.076199
4	0.101599
5	0.126999
6	0.152399
7	0.177798
8	0.203198
9	0.228598

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APPENDIX No. 10.

ON THE CONSTRUCTION OF OBSERVING TRIPODS AND SCAFFOLDS.

By C. O. BOUTELLE, Assistant.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., June 2, 1881.

DEAR SIR: I submit, with this letter, a memoir on the subject of observing tripods and scaffolds, as devised and constructed by me between 1854 and 1879.

I have endeavored to make the paper a practical manual, stating all details which a beginner should know, with tables of all dimensions to which material is to be cut, its size and exact length, etc.

The proportions given start from the floor of the scaffold, at a height of 96 feet, or about 101 feet for the telescope, and apply for any lesser height by simply stopping at the height wanted, *i. e.*, the zero of the tables is the floor at top, and not the ground.

The sketches are of the simplest outline character, to show methods of construction. No elaborate drawing of the structure as a whole is given as it could not be used in construction. I hope this contribution to an important element of success in our triangulations, may be of service in enabling others to profit by my experience.

I desire to call your special attention to the statement in the memoir of the first use by the Coast Survey, in 1868, of position-instruments of large dimensions upon wooden tripods, with the legs of the tripod exposed to the action of the sun while screened from the wind. So far as I have been able to ascertain there is no record of any similar experiment in any part of the world.

Repeating theodolites had been so mounted for many years, but these require only a momentary stability, rarely equaling a minute of time, while turning the telescope from one signal to another. Position-instruments require, on the contrary, either absolute stability for a considerable period or a method of observation which shall eliminate from the resulting directions any error caused by the motion of the tripod. This I have devised and applied in practical observations for thirteen years.

Yours, respectfully,

CHAS. O. BOUTELLE.

C. P. PATTERSON,
Superintendent United States Coast and Geodetic Survey.

Observing tripods and scaffolds were first used upon the Coast Survey by Assistant Edmund Blunt, upon Chesapeake Bay, in 1849. They were also used by Assistant R. D. Cutts, in Texas, in 1850. These last were similar in form to those now used. Those of Assistant Blunt were of an entirely different construction, having a center post and tripod supports, with the legs spread like a signal. Similar ones were used by me in South Carolina in 1850 and 1851, but I found them subject to a vibratory motion, which interfered greatly with precision of observation. To remedy this defect, while engaged in the primary triangulation of the sea-coast of South Carolina and Georgia, in 1854, I devised a form of observing tripod and scaffold which has been largely adopted, with various modifications, by the parties of the Coast Survey in different parts of the United

States. I have used tripods and scaffolds of this form at primary triangulation stations in Maine, New York, Maryland, Virginia, North and South Carolina, Georgia, and Alabama, mounting both twenty and thirty-inch theodolites upon them at elevations ranging from thirty-five to seventy-one feet, with the legs of the observing tripod always exposed to the action of the sun while shielded from the wind by light cotton screens spread upon the windward faces of the scaffold.

A description and sketch of this form was published in the Coast Survey Report for 1855, Appendix No. 57.

In all cases of observation in series with large theodolites mounted on these tripods the resulting directions have equaled in precision those observed with the same instrument upon the ground. The accordance of results by the two methods is well shown in the observations at Hill Station, in Prince George County, Maryland, near Washington. This station was originally occupied by Prof. A. D. Bache, Superintendent, in 1846, with the thirty-inch theodolite, the instrument being upon the ground.

In 1868 I reoccupied the station with the same instrument while extending the primary triangulation from the Kent Island base to the Blue Ridge. To see Sugar Loaf Mountain from Hill it became necessary to elevate the instrument 55 feet. There was no known instance in the history of geodesy where a large and heavy position-instrument had been used at this elevation with the legs of the observing tripod exposed to the action of the sun.

At my request Professor Peirce, then Superintendent, permitted me to try the experiment. To make it a thorough one, I reobserved with the same instrument, at an elevation of 55 feet, the directions observed from the ground by Professor Bache twenty-two years before. The two sets of resulting directions agreed within the probable errors of observation.

The test here applied was as severe as possible, and the result, especially in the general symmetry of the observation, was all that could be desired.

Hill was one of three stations forming the triangle, Hill, Stabler, Peach Grove, at each of which the same instrument was used, in the same manner, upon similar tripods. The triangle closed within less than a quarter of a second to an angle, affording another proof of the possibility of making good and reliable observations with position instruments thus mounted.

Proportions of Tripod and Scaffold.—A proportion found to be perfectly safe is that of one foot radius for every five feet of vertical elevation, so that for a tripod 50 feet high the radius of the circumscribing circle would be 10 feet plus the thickness of the leg of the tripod. A somewhat narrower base is sufficiently safe and more convenient, so that a proportion of one in eight may be used.

Very heavy timbers have been used, usually 8 by 10 inches, for the tripod legs, but it has been found that lighter ones may be used with safety, especially where the structure is built in sections, as hereafter illustrated, tripod legs 6 by 8 inches being sufficiently solid. Their length should be sufficient to allow their tops to meet at a point 4 feet above the floor of the scaffold, while their bottoms are 3 feet below the station point.

For a tripod where the vertical height of the floor of scaffold is 96 feet above the station point the vertical height of each leg would be 103 feet, the radius at bottom $= \frac{103}{8} + 0.667 = 13.542$ feet, and the slant or actual length of each leg would be $\sqrt{103^2 + 12.875^2} = 103.80$ feet. The slope of each upright would be $82^\circ\ 52'\ 30''$.

For the scaffold the square at the floor should be 12 feet. This gives room for setting up either a "platform" or a "hoop" observing tent, each of 4.5 feet radius, with room to walk around the floor outside the tent, and to secure the tent to the rails, bolted to tops of corner posts, 3 feet above the floor.

The half-diagonal of the square at the floor is 8.5 feet from the centre to the outside corner of each upright. These should be six inches square. The proportion of "batter" given each corner post is 2 inches increase of the distance from the centre for each vertical foot below the floor, or one foot in six. The distance from the station to each corner at bottom (3 feet below ground or 99 feet below the floor), would therefore be 198 inches + 8.5 feet = 25 feet, and the side of the square 35.36 feet. The length of each corner post = 103.50 feet, and the slope = $80^\circ\ 32'$.

These proportions would remain the same for any elevation chosen. It is convenient for purposes of construction to make the vertical height of each tier of the scaffold 16 feet, and the height of the floor above ground a multiple of that number as 32, 48, 64, 80, or 96 feet.

Outfit.—For the erection of an observing tripod and scaffold with floor 96 feet above ground, built in three sections, there is required:

A leveling instrument and rod. This may be a gradienter, sector, theodolite, or any instrument capable of being used as a level. For lack of a better I have bored out a piece of sugar-cane, plugged the ends, bored holes in the top at each end, and inserted a couple of apothecaries' phials, with the bottoms uppermost. This, filled with a colored fluid and mounted upon an improvised Jacob-staff, made a very good leveling instrument. A ten-foot pole graduated to feet and decimals answered for a rod.

A couple of portable sectors, or any instrument by which a point in the axis of the station may be found at any elevation, are also needed. No other instruments are wanted.

A 10-foot pole, graduated from the leveling rod to feet and tenths, to be used in laying off all lengths of timber used and distances upon the ground.

A carpenter's chest containing the usual tools. Those specially wanted are two axes, one broadaxe, one adze, three hatchets, two claw-hammers, three small sledge hammers, two combination saws, one rip saw, two iron bars, one level and one "Davis" adjustable level, which may be set to any required slope, and two braces with full sets of auger bits. The sizes $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$, and $\frac{1}{2}$ inch should be in duplicate. They are in constant use in bolting the bracing of both tripod and scaffold, and are liable to be lost, injured, or broken. Three long augers, $\frac{3}{4}$, $\frac{5}{8}$, and $\frac{1}{2}$ inch, are needed for boring the holes for bolts used in splicing the large timbers. It is well to have all the tools in duplicate when working far from any source of supply.

For hoisting gear there is required one large pair threefold iron blocks, with strong swivel hooks. The pulleys should be capable of running freely a fall of $\frac{7}{8}$-inch diameter, and the hooks of sustaining a weight of two tons. Also four double and six single blocks, iron strapped. Four of the single blocks should be fitted with sister hooks.

Of ropes there are wanted: one fall, $2\frac{1}{2}$-inch manila, 420 feet long; two double guys for derrick, $2\frac{1}{2}$-inch manila, each 200 feet; three double guys for tripod legs, $2\frac{1}{4}$-inch manila, each 180 feet; three single guys for tripod legs, $2\frac{1}{4}$-inch manila, each 90 feet; three single guys, extra lines, $2\frac{1}{4}$-inch manila, each 60 feet; four watch-tackle falls, $1\frac{1}{2}$-inch manila, each 60 feet; one coil manila, usual size of tent lines; five pounds tarred marline; eight straps of $2\frac{1}{2}$-inch manila, varying in double length from 3 to 6 feet each. These should be very carefully spliced, as the "drawing" of a splice might cost a life.

These ropes should be carefully examined at each time of using, and any stranded or chafed part removed, since upon their capacity to bear the strain put upon them depends the lives of the persons moving beneath and around them.

Laying out the ground.—If the ground around the station is wooded, a circle of about 100 feet radius should be cleared of trees and undergrowth, to allow room for framing the sides of the scaffold and securing guys. Such trees as stand in good positions may be cut off about two feet above the ground, holes bored in them, and strong pins driven through them to serve as belaying pins for guys. If there is a tree within 10 or 12 feet of the station it may be used for hoisting the derrick, and then cut down and removed.

For a derrick a single stick, not less than 30 feet long and 0.5 foot in diameter at top, can be used. This is supported by two double guys, secured at convenient distances, at right angles to each other. If there are no natural objects, as stumps of trees or rocks, use strong stubs driven down and backed by a split log or board buried in front to help resist pressure, as shown in sketch A, Plate No. 33.

The strap for holding the upper block of the fall is secured to the head of the derrick above the guys, and the free end of the fall is passed through a leading block secured to the foot of the derrick.

The station point is selected and marked by a nail in a stub. The top of the stub is a bench-mark for securing a uniform depth of 3 feet in all the holes, and the nail is the center from which all distances are laid off by the 10-foot pole.

These distances depend upon the proposed height, according to the proportions already given The plan, Fig. 1, page 13, is drawn for a vertical height of 99 feet to the floor of scaffold from bottom of holes, with a middle post for the scaffold up to the top of the second tier, or 32 feet high.

The distances to be laid off from the station point are—

For tripods:

Radius of circle to middle of back of tripod legs $=\frac{103}{8}+0.667=13.542$ feet = distance station point to a, b, and c.

Side of equilateral triangle$=13.542\times1.732=23.46$ feet$=a$ to b, b to c, c to a.

For scaffold:

Distance station point to outside edge of each corner post (page 6)=25 feet. Side of square $=\sqrt{2(25^2)}=35.36$ feet, half of which on each side of the square, or 17.68 feet, will be the distance from the station point and from each corner of the square to the middle of the back of the middle post.

All these points should be laid off upon the ground, roughly, with a tape-line, and stubs driven to mark them. It is convenient to dig only the holes at a, b, and c until the lower tier of the tripod is erected and completed.

The holes are dug each 3.17 feet below the station point. Three shoes are made of the form shown in Fig. 2, page 13. They are 15 by 12 inches, and may be made of two or more pieces of board 1 inch thick, with the grain crossed. On these are nailed three cleats 3 inches wide and 1 inch thick, as in the figure. They are placed at the bottom of each hole, with the point (a) exactly 13.54 feet from the station point and 23.46 feet from (b) and (c), with the surface of the shoe exactly 3 feet below the station and the sides parallel to the radius. Earth is then filled in to keep them in place.

It is evident that if the shoes are carefully set and each tripod leg cut to the same length and bevel, that the three must meet at the top in the vertical of the station point.

It is best to nail three narrow strips together, two of them of the exact length, station point a, etc., and the other $= a$, b, and c, and bring the triangle thus formed successively over the points a, b, c, at the bottoms of the holes, finding the exact positions by plumb-lines dropped from the surface. Similar shoes are placed in the same manner in the holes at the corners and middle posts of the scaffold, except that the corner shoes are made one foot square and cleats nailed, as in Fig. 3. The point ($\times$) is set in the bottom of each hole exactly 25 feet from the station point, with the distance from corner to corner =35.36 feet, and the inner sides of the cleats in the line of the sides of the square.

Framing and hoisting the tripod.—It is not easy to procure timber over 40 feet long. It is better therefore to make each leg out of three pieces and splice them together.

It is most convenient in building to get out three pieces 40 feet, and six pieces of 36 feet each, all 6 by 8 square. I have found a three-foot splice of the form shown in Fig. 4 to be of sufficient strength. Each is held by six bolts of $\frac{5}{8}$-inch round iron, with square heads, nuts, and washers. Two 5-inch "boat spikes" are driven into the thin end of each splice, when it is finally bolted after hoisting.

After fitting the scarf together the holes for the bolts should be bored "drawing" in order to bring the ends of the scarfs very tightly together, and the three pieces bolted so as to form one stick 106 feet long. If any of the legs are winding or irregularly cut from hewn timber, a line should be drawn down the middle of the back of each leg through its whole length, and the chamfers for bearings for the braces should be laid off from this line. The longest of the three pieces should be at the bottom of each leg. The tops of each leg should then be cut to a bevel of 82° 52½′, as in Fig. 5. (This angle is 1¼ inch offset in 10 inches and may be taken from any square by setting the bevel 1¼ inches in, at 10 inches from the corner of the square.)

The lengths to be laid off and the size and dimensions of the braces are as in the following table:

Dimensions of tripod.

Slant dist. from top.	Vert. dist. from top. =L.	R=radius. $=\frac{L}{8}+0.667$.	Length of hor. brace, =1.732 R.	Length of diagonal braces.	Size of braces.
Feet.		*Feet.*	*Feet.*	*Feet.*	*Inches.*
0	0.00	0.667			
5	4.96	1.287	2.229		
8	7.94	1.659	2.873		
13	12.90	2.279	3.947	6.02	3 by 2
20	19.85	3.148	5.452	8.39	3 by 2
29	28.78	4.264	7.385	11.00	3 by 2
40	39.69	5.628	9.748	13.87	3 by 2
53	52.59	7.240	12.540	17.05	3 by 3
68	67.48	9.102	15.765	20.55	3 by 3
85	84.35	11.212	19.420	24.40	3 by 3
103.80	103.00	13.542	23.455	25.00	3 by 3

The distances in the first column should be laid off, measuring with the graduated pole from the top of each leg, along the middle of the leg, and drawing a strong line not easily defaced across each stick at the distances 5, 8, 13, etc., from the top to the bottom at 103.80 where each stick should be sawed parallel to the top, as in Fig. 6.

The inner edge of the top should be cut to an angle of 120° in the middle, so that the three legs when in position will meet at the top, as in Fig. 7.

To give a bearing for the braces a chamfer must be made 9 inches above, and as much below, each line drawn across the back, as in Fig. 8. The chamfer must be 1 inch on the back and $1\frac{3}{4}$ on the side. The natural cot. 30° is 1.73 which is sufficiently near to $1\frac{3}{4}$ to render the chamfered surfaces parallel, when the tripod legs are in position. If the longest (40 feet) stick has been made the bottom one, it will be found that no chamfer comes at a splice.

As little should be cut from the bottom as possible, and whatever amount the leg is too long should be cut from the top, in order that the two lower tiers of braces may come upon the lower section, with the first splice above the second tier of braces. (See Fig. 11.)

The system of bracing for tripod and scaffold is shown in the skeleton sketch, Fig. 11. It is of the simplest character, but has developed sufficient strength to withstand very severe gales. I can vouch for the entire stability of the observing tripod up to a height of 70 feet, and feel sure of it at 100 feet if braced as here drawn.

The bolts being taken out of the splices, a block is temporarily nailed to the upper edge of each splice of the lower sections, as in Fig. 10, to be used in bringing the tops into position after hoisting.

The three lower sections of tripod legs are hoisted to their places in turn. Each has secured to it, about 6 feet below the top, one double and one single guy.

With the foot of each leg in its proper shoe the top is hauled out by the guys until its slope is near the angle of 82° $52\frac{1}{2}'$. This may be found by sawing a pattern from a piece of board with the two sides adjacent to the right angle, respectively 10 and $1\frac{1}{4}$ inches. The hypothenuse will be at the proper slope, which may be set by the cross-level of any carpenter's level. It may be found more readily by setting a "Davis adjustable level" to the required slope. After securing the guys, cleats are nailed on and the tackle is cast off. When all the three are in position, cleats are nailed all the way up, and with one man at the top of each stick, a pattern, Fig. 9, previously prepared, is hoisted and nailed to the temporary block at the top of each leg. If the lower section of each leg is exactly 40 feet from the bottom, then the distance from the top will be $103.80 - 40 = 63.80$ and the radius will be $\frac{63.80}{8} + 0.667 = 8.642$ feet and the equilateral side $= 14.96$ feet. The pattern is made of light strips, with these dimensions, with a strip crossing the centre where a hole is bored for a plumb line.

The tops, secured together by the three pieces, are moved by the guys until the plumb is over the station point, when the holes are filled up to the surface, and the lower tier of braces bolted on with 6-inch boat spikes, boring through the braces and being careful in driving that the lip of the spike cuts across the grain of the tripod leg.

After bolting the lower tier of braces the guys may be removed and the upper tier bolted in the same manner.

Planks are laid across the horizontal braces of the upper tier to form a secure foot for the derrick, which is now raised by a tackle leading from the top of a tripod leg to the foot of the derrick very much as a royal mast is raised on board a ship, a hand at each guy paying out, and keeping the top of the derrick in position as it rises.

When secure, the middle section of each tripod leg is raised and fitted to its splice, which is solidly bolted. Three guys are also attached to each leg, and the same process of adjustment over the centre is gone through with, until the tops are in position, when the third and fourth tiers of braces are bolted. The upper section of each leg is then raised and allowed to rest upon the ground, against the tripod, where it is secured until the scaffold can be framed and the lower sections erected.

Framing and hoisting the scaffold.—The corner posts of the scaffold should be not less than 6 inches square. The lengths of each section are the same as in the tripod, viz, four lower posts 40 feet, eight upper posts 36 feet each. These are spliced in the same manner as the tripod legs, except that I use half-inch bolts 7 inches long, with nuts and washers as before. After splicing, these are framed in pairs, working from the outside corner edge of each post, and laying the cut edges of the splices vertical, as in Fig. 12. The distances from top of post and length and size of braces are given in the following table; the proportion is, as before stated, one in six. The slope of each corner post toward the centre is 80° 32′; toward each other it is 83° 19′, which is the angle at which the bevel should be set:

	Vertical length from top.	Slant length along outside edge.	Slant length along centre post.	Half diag. from station point to outside edge.	Horizont. braces side of square.	Size of horizont. braces.	Diag. braces.	Size of diag. braces.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*
	3	3.05	....	8.49	12.00	3 by 4	....	....
	19	19.27	....	11.15	15.77	3 by 4	21.27	3 by 3
	35	35.49	....	13.82	19.54	3 by 4	23.90	3 by 3
	51	51.71	....	16.49	23.32	4 by 4	26.81	3 by 3
	67	67.93	67.50	19.15	27.08	4 by 4	29.91	3 by 4
	83	84.15	83.60	21.82	30.86	4 by 4	21.66	3 by 3
Ground............	99	100.38	99.70	24.50	34.65	....	*22.23	3 by 3
Bottom of holes.....	102	103.42	102.72	25.00	35.36	....	....	....

* One foot from ground.

No line is cut square, but all are cut to the bevel, from the outside corner. The top being cut to the bevel all around, if the post is 6 inches square, the interior diagonal corner will be found to be 1 inch higher than the outside corner.

The posts after splicing being laid near each other in pairs, the distances in the second column of the table must be laid off carefully along the outside edges, a line being drawn with the bevel upon the upper surface at each mark, and others 4 and 8 inches below it, on the exterior sides. A mortise three-fourths of an inch deep is cut between the lines, to receive the horizontal braces, each 3 by 4 inches in size. The mortises upon the sides are 4 inches below those upon the top, as in Fig. 13. The bottom of each post is cut parallel to the top. It will be level when the scaffold is in position.

The length of horizontal braces given in the table, page 22, is for the upper side. They are to be laid in pairs and sawed to the bevel of the scaffold and marked as in Fig. 14. The upper braces will fit the upper mortises (*a*) Fig. 13, and the lower, marked "sides," will fit the lower mortises (*b*) Fig. 13. After all these are got out, a side of the scaffold is framed and bolted upon the ground, as in Fig. 12, except that the diagonal braces are not bolted at the splices.

The horizontal and diagonal braces of the two lower tiers may be either bolted or mortised into the middle upright, which may be cut and roughly hewed upon the ground.

For bolting, 6-inch pressed "boat spikes" should be used, boring through the braces and bolting into the posts. With care, any twist or wind in the three long parts of each upright may be taken out in framing. The frame should be laid with the *top* of each side near the tripod and on opposite sides of it.

After framing the scaffold, the bolts at the splices are withdrawn, leaving each side of the scaffold in three sections. The upper and middle sections are successively hoisted and allowed to rest against the tripod with their lower ends upon the ground close to the tripod and inside the square the scaffold is intended to cover.

The holes for the scaffold are now dug, and the shoes at the corners carefully secured in position and level as described on page 13. Each lower section of the scaffold is now hoisted and placed in position, with every post in its proper shoe, and is secured temporarily to the tripod with the middle of each diagonal in the vertical of the station point after which the holes of the corner posts are filled. The side centre posts are next raised, secured temporarily to the tripod, and the sides are braced.

To secure the four centre posts from sagging inward, four horizontal braces or girders are added after all parts of the scaffold have been hoisted, as shown in Fig. 15. They may be made from 4 by 4 inch scantling 20 feet long.

After the lower section of the scaffold is in position and braced, the middle section is hoisted into position and the splices fitted and bolted. Care should be taken to insure that the centre of the square of the scaffold is identical with the centre of the interior tripod, to which it is temporarily secured until the sides are braced.

The scaffold being now of the same height as the tripod, a temporary platform of boards is laid upon the horizontal braces of the scaffold and tripod, and the derrick is again hoisted as before, when the upper section of the tripod is raised, one leg at a time, spliced and braced in the same manner as before. Very long guys are needed to both derrick and tripod legs while erecting this section, and it is for this purpose that the longer ropes described on page 9 are required.

If due care has been taken in framing and hoisting the tripod, it will be found that the three upper sections when fitted to their splices will meet at the top very near the vertical of the station point; so near that a person ascending upon cleats may easily spring them together if it cannot be done by the guys.

The horizontal and diagonal braces are bolted, the tripod is completed, and the derrick may be removed.

The tripod is now used as a derrick to hoist the upper section of the scaffold, which is raised, spliced, and secured temporarily to the tripod while the sides are braced.

While framing the scaffold upon the ground, and before taking it apart for hoisting, cleats should be strongly nailed to each upright, parallel to the horizontal braces and fifteen inches apart, from the floor to the ground. They may be made from "strips" 3 by 1 inches, and should be each 14 inches long, so as to give a secure foothold extending four inches outside of each edge of the upright. They are constantly used when the station is occupied, in extending or taking in the light cotton screens used to spread upon the windward sides of the scaffold to keep the wind from disturbing the interior observing tripod, which supports the instrument when observing. It is also convenient to duplicate each set of diagonals of the scaffold-braces after the set upon the ground are bolted, by laying another set over them for use upon the sides of the scaffold, cutting them to the same size, boring the holes for spiking, and, especially, clinching them by a spike at their intersections. Much time will be saved by this precaution.

The side horizontal braces of the scaffold are 4 inches below the others at each tier. Sleepers of 3 by 4 inches laid upon these support platforms at each tier, and stairways are laid from each tier to the next around the sides of the scaffold. A convenient and quickly made form of stairway is formed by two planks, with grooves cut in them for the admission of steps (Fig. 16.) It is best to so arrange the stairways that the last one shall be parallel to the sleepers on which the floor is laid. The following table gives the dimensions of stairways for each tier. The rise or vertical height is 16 feet or 192 inches in each. The horizontal distance is least at the first or uppermost tier. Each side of a stairway is a single plank 2 inches thick and 12 inches wide, grooved as in Fig. 16.

Dimensions of stairways in inches.

Tier.	Horizont. length.	No. of steps.	Rise per step.	Tread per step.	Slant per step.	Whole length.	Remarks.
1	130	21	9.14	6.20	11.04	2,319	Upper edge rests against inner side of post and horizontal brace.
2	139	21	9.14	6.62	11.29	2,370	
3	178.5	21	9.14	8.50	12.46	2,622	
4	189	21	9.14	9	12.83	2,694	
5	189	21	9.14	9	12.83	2,694	
6	189	21	9.14	9	12.83	2,694	Bottom rests upon a block set in the ground.

The steps may be cut from boards 8 to 6 inches wide, each 24 inches long. As the stairways may be made under cover they furnish occupation for the workmen on rainy days, when outside work is interrupted. The distribution of the sleepers for support of the floor is seen in Fig. 17. The figure represents the centres of the observing tripod and scaffold as coincident. In practice they are like to vary from 1 to 2 inches. Allowance must be made for this, if it occurs. A small frame laid in the centre, as in the figure, will be convenient to give much support to the floor boards at the points where they are cut.

A free space of an inch should be allowed all around the tripod legs, and before laying the floor all connections between tripod and scaffold used in building should be carefully severed, that each may take its own position independent of the other. Diagonal supports under the outside horizontal braces supporting the floor should be bolted, as shown in Figs. 11 and 12.

The scaffold rail around the top of the uprights is of 3 by 2 inch scantling, planed and rounded at the corners. A similar rail is also bolted to blocks 2 inches thick around the scaffold at the floor. It is used to hold the top of the light cotton screens spread upon the windward faces of the scaffold during observations. A light rail around the inside of the stairways will also be found convenient. The tables, of dimensions and proportions given in this paper, will apply for any elevation below 96 feet, since all count from the top. For a height of 48 feet to the floor the tripod legs and scaffold sides may be hoisted whole without difficulty. For a height of 64 feet it will be best to build in two sections, taking the splices apart after framing. No middle post is necessary for the lower tiers of the scaffold at either of these elevations.

I insert here a table of lengths of tripod and scaffold posts for different elevations.

Dimensions in feet.

	TRIPOD.				SCAFFOLD.			
Vertical height of floor above station point.	Vert. length.	Slant length.	Three feet below station point.		Vert. length.	Slant length.	Three feet below station point.	
			Rad. +0.67	Side of eq. triangle.			One-half diagonal.	Side of square.
32	39	39.31	5.54	9.60	38	38.52	14.33	20.26
48	55	55.43	7.54	13.06	54	54.75	17.00	24.04
64	71	71.55	9.54	16.52	70	70.97	19.66	27.80
80	87	87.68	11.54	19.99	86	87.19	22.32	31.57
96	103	103.80	13.54	23.45	102	103.41	25.00	35 35

With workmen trained to their duties, and accustomed, like seamen, to work at considerable elevations, held in position at first by ropes only, a week of clear weather will suffice to build one of these structures of not more than 64 feet elevation. For one of a height of 96 feet, twelve working days will suffice. I have put up one 45 feet high in two days with a force of sailors, and using sawed yellow pine lumber.

It is best to avoid the use of cut nails when possible. They are largely made from iron of a very poor quality. Square pressed boat spikes, 4, 5, and 6 inches in length, are preferable. All kinds of woods may be used. In the Southern States the yellow pine is best, as being strongest (and also heaviest) and the cypress is to be avoided. It warps and cracks badly in seasoning. I have used oak and chestnut and also spruce, fir, and white pine, with success in the Middle and Northern States.* In places where sawed material cannot be had, and forest timber abounds, it will be found best to hew the tripod and scaffold legs into shape before splicing and framing them. Round sticks, chamfered at the ends and notched at intersections, make good diagonal braces. Whether round or sawed lumber is used, great care should be taken to see that the longer braces are free from knots and shakes, weakening them where strength is most needed.

The following "bills" or lists of sawed lumber required for structures 48 and 96 feet of elevation will be found sufficient. The prices range from $8 to $25 per 1,000 feet, depending on locality and material.

For 48 feet elevation of floor.

Tripod legs: Three pieces, 6 by 8 inches, 35 feet long; three pieces, 6 by 8 inches, 25 feet long.

Scaffold legs: Four pieces, 6 by 6 inches, 35 feet long; four pieces, 6 by 6 inches, 25 feet long.

Horizontal bracing: Eight pieces, 3 by 4 inches, 14 feet long.

Horizontal bracing: Ten pieces, 3 by 4 inches, 18 feet long.

Horizontal bracing: Five pieces, 3 by 4 inches, 22 feet long.

Diagonal bracing: Thirty pieces, 3 by 2 inches, 25 feet long.

Diagonal bracing: Ten pieces, 3 by 3 inches, 22 feet long.

Diagonal bracing: Ten pieces, 3 by 3 inches, 28 feet long.

Stairways: Six 2-inch planks, 25 feet long, 1 foot wide; four hundred feet boards, 12 to 14 feet lengths; 200 feet (running measure) of 3 by 1 inch strips.

Also for splicing: Forty-two bolts with square heads 7 inches long, of $\frac{5}{8}$-inch round iron, with 42 nuts and 84 washers.

For bolting braces: Two hundred and fifty pressed boat spikes 6 inches long, and one hundred and fifty spikes of 5 inches long.

For nailing cleats, stairways, platforms and floor, there are wanted 60 pounds of 10*d.* and 20 pounds of 8*d.* nails. A dozen bolts of $\frac{1}{2}$-inch round iron, with nuts and washers, will be useful.

In framing a tripod and scaffold of this elevation, the shorter or 25 feet lengths of the posts should be made the lower ones. It may be raised whole, but it will be found more convenient to raise any greater height in sections.

For 96 feet elevation of floor.

Three pieces, 6 by 8 inches, 35 feet long; six pieces, 6 by 8 inches, 40 feet long.

Four pieces, 6 by 6 inches, 35 feet long; eight pieces, 6 by 6 inches, 40 feet long.

Eight pieces, 4 by 4 inches, 14 feet; eight pieces, 4 by 4 inches, 16 feet; twelve pieces, 4 by 4 inches, 18 feet.

Sixteen pieces, 3 by 4 inches, 14 feet; twelve pieces, 3 by 4 inches, 16 feet.

Six pieces, 3 by 4 inches, 18 feet; six pieces, 3 by 4 inches, 22 feet.

Twenty-seven pieces, 3 by 3 inches, 21 feet; 24 pieces, 3 by 3 inches, 23 feet.

Thirty-two pieces, 3 by 3 inches, 25 feet; sixteen pieces, 3 by 3 inches, 27 feet.

Twenty-four pieces, 3 by 2 inches, 10 feet; twelve pieces, 3 by 2 inches, 12 feet; ten pieces, 3 by 2 inches, 16 feet.

Ten pieces, 3 by 2 inches, 20 feet; six pieces, 3 by 2 inches, 25 feet.

Four hundred feet (running measure) 3 by 1 inch.

Twelve planks, 12 by 2 inches, 25 feet long.

Four hundred feet boards 8 by 1 inches lengths, 10 to 15 feet.

Three hundred feet boards 12 by 1 inches lengths, 12 to 16 feet.

In all about 8,500 feet of material.

Also for splicing, eighty-four bolts with square heads, 7 inches long, of $\frac{5}{8}$-inch round iron, with eighty-four nuts and one hundred and sixty-eight washers. Twenty bolts like above, 6 inches long, of $\frac{1}{2}$-inch round iron, with nuts and washers. Two casks, of 100 pounds each, of 6-inch and 5-inch pressed boat-spikes.

* Hemlock for bracing is to be avoided if possible, but where no other wood is procurable, the size of each brace should be increased to render them equal in strength to the sizes given for yellow pine as in the tables. The same remark applies to others of the softer kinds of wood.

For wire guys, 300 yards of wire rope $\frac{3}{8}$-inch in diameter, and twelve turnbuckles.

This "bill" does not include the four middle posts for the two lower tiers of scaffold, which may be cut and hewed. If ordered at saw-mill, order eight pieces, 6 by 6 inches, 35 feet long, instead of four pieces, as in the "bill."

The chief of party should give his personal attention to the following points:

1. That his material is sound and free from knots or shakes.
2. That his tackle, straps, and guys are sound, strong, and nowhere rotted, chafed, or stranded.
3. That every knot where guys are secured, or pieces of rope knotted together, is securely made in a proper manner, and that no slipknots or "grannies" are put in by inexperienced men. The lives of himself and men depend on care in these respects.
4. That every measurement is carefully made by a common standard, which should *never* be a tape-line.
5. That every stick is cut to its proper bevel and length, so that each part may fit when hoisted to its place.

Too much care can hardly be bestowed upon these matters, on which the final strength and solidity of the whole structure depends.

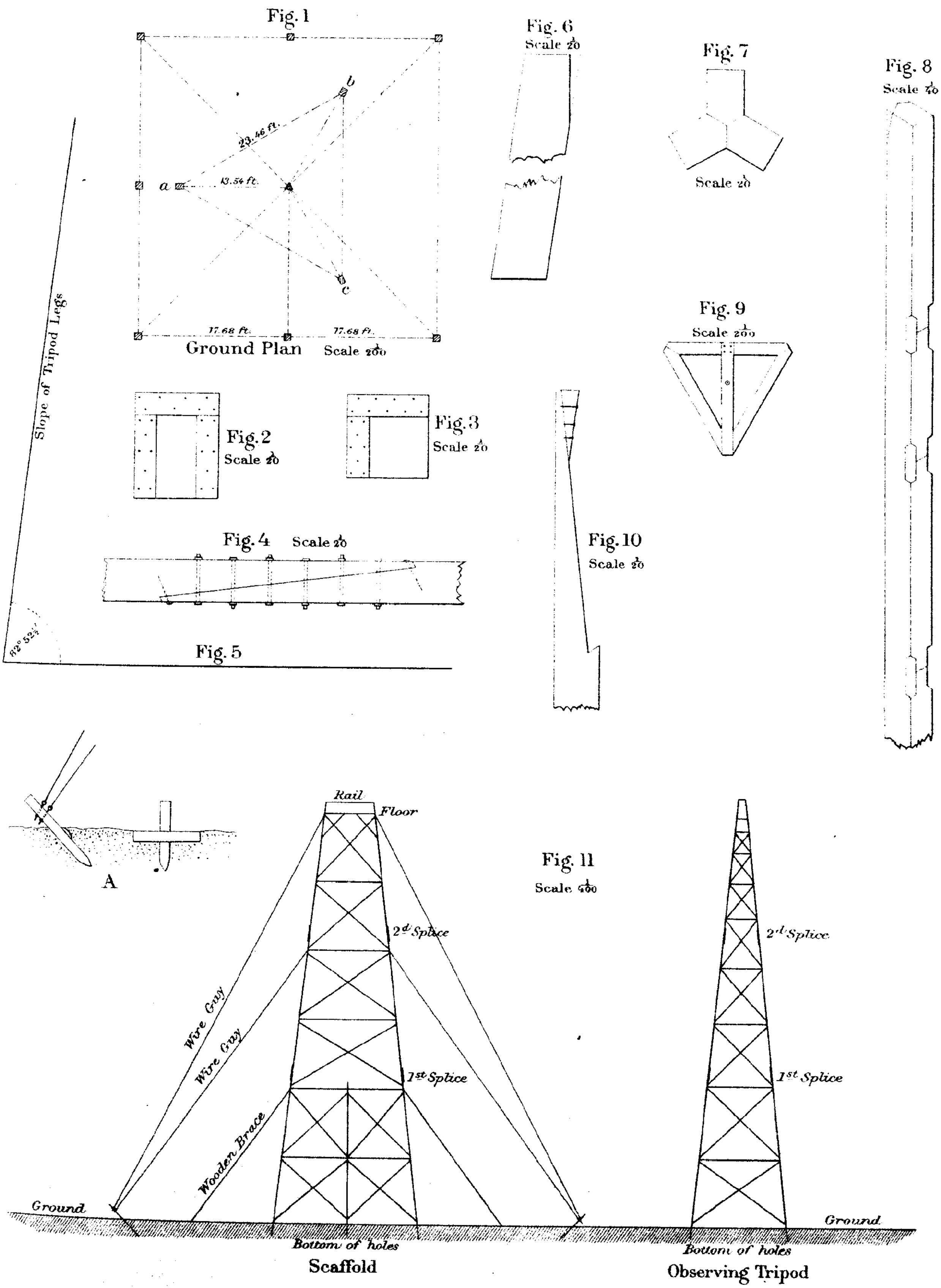
It has been found by experience that the twist of the legs of the tripod, consequent upon the sun's action, has, at times, been very great, amounting in some extreme cases to a difference of three minutes in readings upon the same signal a. m. and p. m. But the torsion did not commence a. m. until the morning observations were over, and usually the full effect of the sun's action had taken place before the p. m. observations began.

The afternoon readings upon the same signal were usually less than in the morning, showing that the twist was in the direction of the sun's apparent motion.

In order to correct for any uniform motion while making observations, it has been my practice to begin observing a series from left to right, with the reference-point observed in the middle of the series; then reversing the telescope, observing from right to left in the same order. If the times of observation are about equal and the tripod carrying the instrument is steadily moving in either direction, then the mean differences of reading between the reference-mark and signal observed will be unaffected by the tripod's motion.

The principle of construction aimed at has been to obtain a maximum of strength and solidity with a minimum of surface exposed to the action of the winds.

C. O. BOUTELLE,
Assistant, Coast and Geodetic Survey.



Skeleton sketch showing system of Braces for a Tripod and Scaffold with floor 96 feet high

Fig. 12
Scale $\frac{1}{200}$

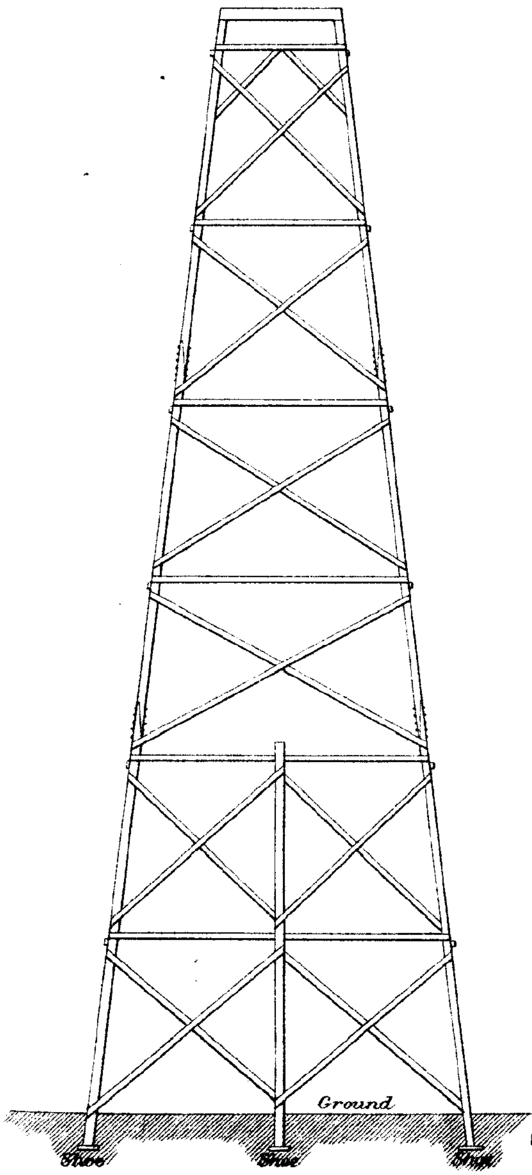


Fig. 13
Scale $\frac{1}{40}$

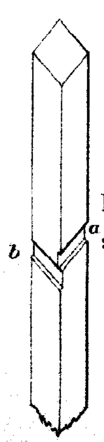


Fig. 14 Scale $\frac{1}{40}$

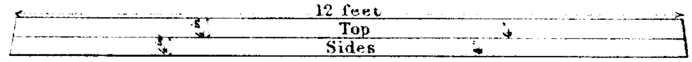


Fig. 15 Scale $\frac{1}{100}$

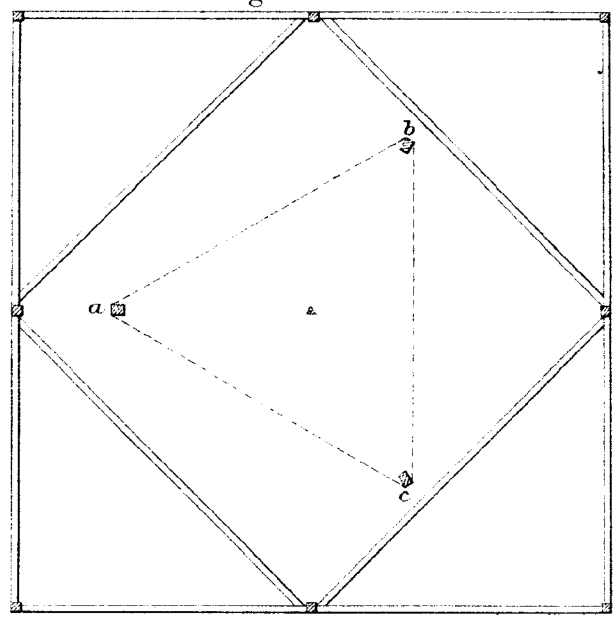


Fig. 16 Scale $\frac{1}{100}$

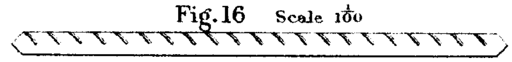
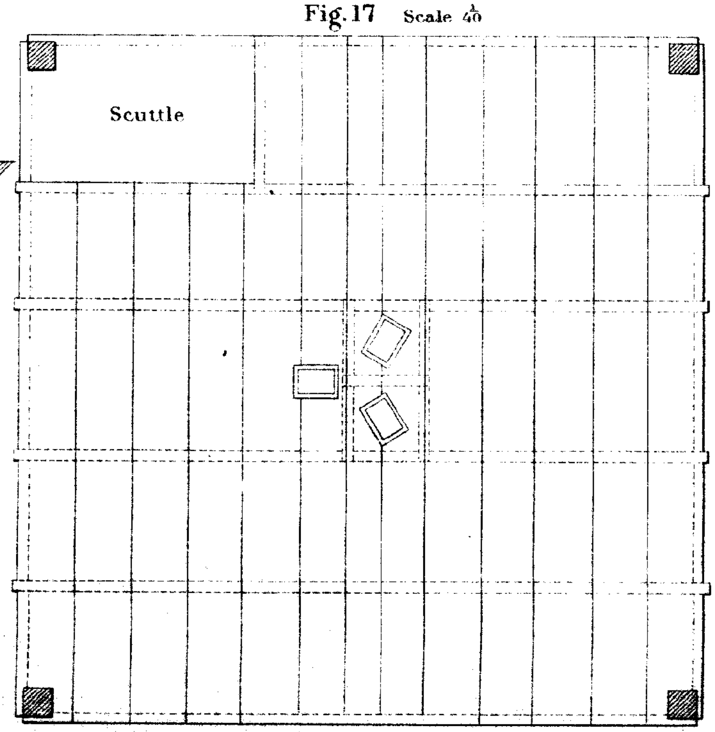


Fig. 17 Scale $\frac{1}{40}$



Plan of Floor of Scaffold

APPENDIX No. 11.

RESULTS OF THE TRANSCONTINENTAL LINE OF GEODETIC SPIRIT-LEVELING NEAR THE PARALLEL OF 39°, EXECUTED BY ANDREW BRAID, ASSISTANT, UNITED STATES COAST AND GEODETIC SURVEY.

By CHARLES A. SCHOTT, Assistant.

PART I.—FROM SANDY HOOK, N. J., TO SAINT LOUIS, MO.

This Appendix will be found following Appendix No. 22 of the present volume.

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APPENDIX No. 12.

ON THE SECULAR VARIATION OF THE MAGNETIC DECLINATION IN THE UNITED STATES AND AT SOME FOREIGN STATIONS.

By CHARLES A. SCHOTT, Assistant Coast and Geodetic Survey.

[Fifth edition, November, 1882.*]

The present investigation incorporates many additional observations made and results collected since June, 1881 (date of the last edition), and contains the extended and improved results of old stations as well as those for a number of new localities, several of which are in Alaska; comprising altogether 82 stations with about 837 results. The geographical range of the discussion includes stations irregularly distributed over the whole of the United States, a station in Europe, a station in Brazil, two on the Sandwich Islands, and one in Asiatic Russia.

The demand for the contents of this article has been constantly on the increase, not only by scientists and surveyors, but also by lawyers, the latter demands arising chiefly from cases of disputed land boundaries, which originally had been run by compass and are now required to be retraced. To render this investigation more useful to practical men, I have thought it desirable to preface it by a brief account of the various and principal motions, systematic and irregular, to which the direction of the magnetic needle is subject, and thus clearly to separate and distinguish these changes from the secular variation, which alone is here the special object of treatment. Theoretically, a knowledge of the secular variation is of great importance, and practically, is indispensable in order that the coast charts published by this office may be supplied with the variation of the compass for the date of issue.

The magnetic declination (or variation of the compass, as it was formerly called by surveyors and still is by navigators), at any place, is the angle contained between two vertical planes, one being the astronomical or true meridian, and the other a plane in which the horizontal axis of a freely suspended magnet lies at the time. The former plane is fixed and the latter variable, since it is found that the needle is in a state of a small continual motion. The magnetic declination varies with respect to space and time; it is, therefore, necessary to give with the statement of its measure the exact time (year, day and hour) when an observation was made, as well as the geographical position of the place (the latitude and longitude to the nearest minute of arc will suffice). The declination is called "west" when the *north* end of the magnet points to the west of true north; algebraically this fact is indicated by a + sign, and if "east" by a − sign. It is a matter of observation that the magnet, when light and delicately suspended (by a single fiber of raw silk) is seldom or never at rest, but is always shifting its direction, or is in a state of oscillation or of tremor, or it may be of sudden changes. These angular motions have been classified as regular

* This article originally appeared in Coast Survey Report for 1859, Appendix No. 24, pp. 296–305. In the second edition, in Coast Survey Report for 1874, Appendix No. 8, pp. 72–108, the investigation appears greatly extended; the substitution of a sine for a cosine function was made and the epoch was changed from 1830 to 1850; also some use was made of Cauchy's method of interpolation for the establishment of some second periodic terms. The third edition, issued in June, 1879, appeared in pamphlet form, and is not contained in any annual report of the Coast and Geodetic Survey. The geographical range of the investigation was much enlarged, and the paper was illustrated by two plates. The next or fourth edition was brought out in June, 1881, and forms Appendix No. 9, Coast and Geodetic Survey Report for 1879, then passing through the press; it was illustrated with three plates.

(periodic) and irregular variations, and of these we propose to notice briefly the principal ones, such as may generally be exhibited within the limits of the United States.

The *solar-diurnal* variation consists in a systematic movement of the magnet, having for its period the solar day. Its character is the same for the greater part of the northern hemisphere, viz, about the time of sunrise the *north* end of the needle is generally found approaching to or near its most *easterly* deflection from the average magnetic meridian. This phase happens, for instance, at Philadelphia, on the yearly average, about $7\frac{3}{4}^h$ a. m.; at Key West, Fla., about $8\frac{1}{4}^h$ a. m.; and the same at Madison, Wis. It is subject to an annual variation, being about $\frac{3}{4}$ of an hour later in the months when the sun is south of the equator, and about $\frac{1}{2}$ of an hour earlier in the summer months than its yearly average epoch. The north end of the needle then begins its principal daily motion, and reaches the opposite extreme position, or its western elongation, about half past 1 o'clock p. m. It is reached a few minutes earlier in summer and a few minutes later in winter, and hardly varies half an hour for different localities. After this epoch the needle takes up an easterly movement and gradually returns nearly to the direction from which it set out in the morning. Frequently an interruption, or small reversed motion, is exhibited during the night. At Philadelphia the average daily direction is reached in summer about $10\frac{1}{4}^h$ a. m. and in winter about $10\frac{3}{4}^h$ a. m., and generally within half an hour of these times at other places. The magnetic meridian is crossed a second time, generally between 7 and 9 p. m. The angular range between the morning and afternoon elongations, or the diurnal range, is about $8'$ on the average at Philadelphia and about $5\frac{1}{2}'$ at Key West; in higher magnetic latitudes more, in lower less. This range is subject to an annual inequality, being much more conspicuous in summer than in winter ($10\frac{1}{2}'$ at Philadelphia in August and $6'$ in November). It is further subject to a periodic inequality related to the eleven-year cycle of the sun-spots. It is least in years of minimum sun-spots (as in 1878, for instance) and greatest in years of maximum sun-spots (as in 1870) the factors being 0.7 and 1.3, about, of the average amount of these years respectively. This daily variation appears at times intensified, at other times enfeebled, and during the winter months there are occasionally days on which it cannot be recognized. Observations must be corrected for time of day in order to reduce the result to the average direction of the twenty-four hours; a table given for this purpose is found in Coast and Geodetic Survey Report for 1881, Appendix No. 8, Art. 6.

The *annual variation* of the declination is so small that a mere mention of its existence suffices; its amplitude is at most $1\frac{1}{2}$ minutes of arc.

The lunar inequalities: These we likewise pass over on account of their small amplitude. The principal inequality is the lunar diurnal variation exhibiting the peculiarity of two maxima and two minima on each lunar day. The range of this inequality at Philadelphia is about $27''$, and at Toronto, Canada, about $38''$. Other lunar inequalities are of yet smaller order.

The secular variation of the magnetic declination, our subject proper, is most probably also of a periodic character, but since it requires centuries for its full development, and since, as yet, no one cycle has actually been completed within the range of observation, we are obliged, in the absence of any reliable theory, to follow up the phenomena by continuous observations. Thus from time to time our previous deductions or supposed laws need changing or amending in order to preserve the required harmonious relations with facts. The secular motion may be compared with a wave motion or with an oscillation of a pendulum which comes to rest momentarily at its extreme positions or elongations and moves fastest midway between these extremes. Smaller variations within this period have also been detected, but the general angular movement (say of the north end) of the magnet may be described as follows: About the times of maximum deflection the magnet appears almost stationary or only slowly oscillating about the same average direction (to ordinary or rough instruments) for several years; soon, however, the effect of the secular change becomes perceptible, increasing gradually, year by year; the progressive angular motion soon reaches an annual maximum value, after which, still moving in the same direction, it slowly diminishes, becoming stationary at the opposite extreme digression and possibly returning again to its first position. Within the area of the United States and south of latitude 49° a complete oscillation of this kind may require between two and a half and three and a half centuries, during which time the magnet would swing twice, once forward and once backward, through an arc of several degrees, generally keeping within the limits of 3° and 7° of total range for our geographical boundaries; in other localities the period and range are very much greater. The remarkable regularity of the motion is well shown on the accompanying diagram for Paris, France, for which place we probably possess the longest series of observations; the period is about four and two-thirds centuries, and the range nearly 33°. To illustrate further the effect of the secular change, we may take the case of New York City. In this locality the needle was observed to be in nearly a stationary condition about 1685, its north end pointing then 9° to the west of north; it then moved easterly and reached its easternmost digression about 1797, showing at that time only 4° west declination. Ever since this epoch the motion has been westerly, its present value being nearly 8° W.; the greatest annual change (nearly 5′) has apparently been passed. The times of these stationary epochs are different at different localities; the last epoch was noted earliest in Maine, later in Florida and Texas, and has not yet been reached in California. At present, all along our Atlantic and Gulf coasts and over the middle and eastern parts of the United States, the effect of the secular change is to *increase* west declination, or (what is the same) to *decrease* east declination; but on the Pacific coast and for some distance interior the effect is opposite, viz, an *increase* of east declination. Alaska, however, is to be excepted; there easterly declination seems to decrease slowly. There must, consequently, be a region of no present change, which will be referred to in detail further on. It is this regular motion, known as the secular variation, which renders it necessary to reconstruct from time to time our isogonic charts. Although this secular variation is perfectly systematic it may not always appear so, especially when deduced from few observations made at different stations in the same general locality, either on account of small observing errors and possible local deflections, or for the reason that ordinary periodic variations and disturbances have not been fully eliminated. Among the latter must be classed the—

Magnetic disturbances.—These may occur at any time, and are, when taken individually, beyond the power of prediction; but attacked by the statistical method, *i. e.*, when classified and averages are taken of many thousands, they are found to be subject to various laws. Their presence is generally indicated by sudden deflections, and by rapid and great fluctuations in the direction of the needle as compared with its normal position, which otherwise might have been expected. They often take place simultaneously at distant regions of the globe, and in duration may be confined to a few hours, or they may last a day or even for several days. They are frequently accompanied by auroral lights and by strong electric earth-currents. When analyzed in large numbers they exhibit a solar-diurnal variation, the westerly and easterly disturbances, however, following different laws. They also have an annual variation and seem to depend largely on the sun-spot period or an eleven-year cycle. Irrespective of direction of the disturbing forces the most disturbed hours of the day are generally those between 7^h and 10^h a. m., and the least disturbed those between 2 and 6^h p. m. Westerly disturbances occur most frequently about 8^h a. m. and least about 8^h p. m; they exhibit a *single* daily progression. Easterly disturbances reach a maximum about 8^h p. m. and a minimum about 2^h p. m.; they exhibit a *double* daily progression. Westerly and easterly disturbances appear to agree in their annual variation, in their times of maxima, *i. e.*, in August, September, and October, and in their times of minima, *i. e.*, in January and June. The disturbances are most frequent and considerable in years of maximum sun-spot activity and the reverse in years of minimum sun-spots. The following table of the observed disturbances, in a bi-hourly series at Philadelphia in the years 1840 to 1845, will give an idea of their relative frequency and magnitude:

Deviations from normal direction.	Number of disturbances.
3′.6 to 10′.8	2189
10′.8 to 18′.1	147
18′.1 to 25′.3	18
25′.3 to 32′.6	3
Beyond......	0

At Key West, Fla., the maximum deflection noticed between 1860 and 1866 was 21′.4 At Madison, Wis., where the horizontal magnetic intensity is considerably less, very much larger deflections have been noticed. Thus, on October 12, 1877, one of 48′ and on May 28, 1877, one of 1° 24′. We now proceed to the consideration of the secular variation of the magnetic declination.

HISTORICAL NOTE.

The following brief historical remarks on the magnetic declination and its secular variation have been prepared from extracts from Humboldt's Cosmos (Otte's translation, London, 1849–1858), vols. II and V; from the Encyclopædia Britannica, 9th edition, Art. Compass, vol. VI (Boston, 1877), and from E. Walker's treatise "Terrestrial and Cosmical Magnetism," Cambridge (England), 1866, in which works fuller references will be found. The Encyclopædia of Experimental Philosophy, London, 1848, Art. Magnetism, as well as Gehler's Physikalishes Wörterbuch, Leipzig, 1825, Art. Compass, were also consulted.

The first notice of the magnetic needle as applied to navigation we meet with among western (European) nations does not date further back than the eleventh or twelfth century of our era, but in China the directive property of the magnetic needle was made use of on land as early as the twelfth century B. C., and, according to tradition, even at a very much earlier time (2634 B. C.) In the third and fourth centuries of our era Chinese vessels were guided by the magnetic needle, and through them a knowledge of the polarity of the needle was conveyed to India and thence westward. In the ninth century Chinese merchants traded in ships to the Persian Gulf and the Red Sea. Probably through the influence of Arabian navigators, or through the agency of the Crusaders, the use of the mariners' compass was introduced into Eastern Europe. Among the first European writers of the middle ages who refer to the loadstone or to the compass is the Icelandic historian, Are Frode, who lived about the end of the eleventh century. He states that the directive property of the loadstone was then known to seamen in northern countries. Next are mentioned, Alexander Neckam, in two treatises, "De Utensilibus" and "De Naturis Rerum," of the twelfth century, Guyot, of Provins, in 1190, and Jaques de Vitry, between 1204 and 1215. Raymond Lully, in 1272 and 1286, remarks that the seamen of his time employed the magnetic needle, and from Torfæus we learn that the compass was in use among the Norwegians about the middle of the thirteenth century. Among western nations the construction of the instrument underwent great improvements, particularly by the hands of Flavio Gioja, of Amalphi, Italy, in 1302.

The declination.—From a Chinese work, written between 1111 and 1117 A. D., we learn that the needle was then suspended by a thread and that the mode of measuring the amount of the declination, it being then west (or, as there expressed, east of south), had long been understood. It can hardly be supposed that the fact of the needle, in general, not pointing to the true north and south could have been overlooked in the twelfth century, on the Mediterranean, in places where the declination reached 6° to 10°. A passage interpolated in a Paris MS., a copy of "Epistola Petri Peregrini," &c., of 1269, states the declination to have been determined by him in Italy at 5° E. Columbus probably was the first who records the change in the sign of declination with change of position. On starting from the west coast of Spain he had east declination. In September, 1492, in the Atlantic, in latitude 28° longitude 28° (about) he observed 11° W. He has also the merit of being the first to discover a part of an agonic line, or line of no declination. The first scientific work in Europe in which the declination is treated at any length and deduced from actual observations is that by Boroughs, published in 1581, entitled "A Discourse on the Variation of the Cumpas or Magneticall Needle," and is dedicated to the "travaillers and mariners of England." In 1599, Prince Maurice, of Nassau, the lord high admiral of the Low Countries, recommended seamen to keep a register of the declination in every part of the world they might visit.

Isogonic charts.—The declination was marked on the chart of Andrea Bianco, drawn up in the year 1436, and Alonso de Santa Cruz, in 1530, constructed the first general declination chart, though based upon very imperfect material. Upon the chart by Father Christopher Burrus (died in 1632), published at Lisbon, the lines are called "tractus chalyboeliticos." About 170 years after Alonso de Santa Cruz, Edm. Halley published his celebrated isogonic chart for the year 1700, based entirely upon observations. [Tabula Nautica, Variationum Magneticarum Index, juxta observationes anno 1700.] His voyages of the years 1698, 1699 and 1702 were undertaken at the expense of the British Government. This chart comprises the areas of the North and South Atlantic, the Indian, and the extreme western part of the Pacific Ocean. Isogonic charts became quite numerous after Halley's time. Those by Hansteen (Magnetismus der Erde, 1819) deserve special mention; his earliest one is for the year 1600. In 1838 Gauss published his "General theory of Terrestrial Magnetism" (in Resultate, etc., des Magnetischen Vereins) and the resulting isomagnetic curves were afterwards charted. A translation of the theory and the charts are given in Taylor's Scientific Memoirs, Vol. II, London, 1841. In the work of A. Erman and H. Petersen, "The Foundation of the Gaussian theory and the phenomena of Terrestrial Magnetism in the year 1829," Berlin, 1874, the general distribution of magnetism over the globe is shown on six charts for the epoch 1829. For the most complete magnetic charts depending directly on observations, the reader is referred to General Sir Edward Sabine's Contributions to Terrestrial Magnetism, Nos. XI, XIII, XIV and XV, Phil. Trans. Roy. Soc., for the years 1868, 1872, 1875 and 1877, respectively. These charts refer to the epoch 1840 to 1845. Isogonic charts for the United States of North America, in three sheets, Nos. 37, 38, 39 and reduced to the epoch 1885.0, will be found in this report (see Appendix No. 13.)

The secular variation of the declination.—The discovery of the gradual change of the declination, which for any one place had previously been supposed constant by philosophers, is due to Gellibrand, of Gresham College, England. In 1635 he published his work, entitled "A discourse mathematicall on the Variation of the Magneticall Needle, together with its admirable diminution lately discovered." He based his conclusions upon the recorded observations of Boroughs (1580), of Gunter (1622), and his own observations (1633–34), showing that in the vicinity of London the direction of the needle had changed in the interval fully 7° to the westward. From this time the fact of the secular variation was completely established, and it remained to later times to determine its extent and develop the law governing this change, and to endeavor to find its cause. That the velocity was not uniform was soon perceived, and the apparent periodic character of the variation was prominently forced upon the attention of observers when the needle reached a stationary condition, as, for instance, in the eastern part of the United States towards the end of the eighteenth century, and then recommenced its motion in a direction *opposite* to that it had before. Similarly at Paris, France, the secular change was westward between the stationary epochs of 1580 (about) and 1814 (about), since which time the needle has been retracing its course eastwardly. Nearly midway between such stationary epochs the annual change is observed to be a maximum. See Plate No. 36, upper diagram.

ANALYTICAL EXPRESSION OF THE SECULAR VARIATION OF THE MAGNETIC DECLINATION.

The secular variation can be represented with considerable accuracy by means of a circular or harmonic function, as might be expected from the almost unlimited adaptation of such functions to all forms of periodically recurring phenomena, provided a sufficient number of terms are introduced. The formula employed for our purpose may be written—

$$D = \delta + r \sin (\alpha m + c) + r_{\prime} \sin (\alpha_{\prime} m + c_{\prime}) + r_{\prime\prime} \sin (\alpha_{\prime\prime} m + c_{\prime\prime}) + \ldots\ldots\ldots$$

Where D = magnetic declination at any time t, positive when west, negative when east.

m = number of years and fractions of a year from an epoch t_0 for which 1850 has been adopted; hence $m = t - 1850.00$

$\alpha\ \alpha_{\prime}\ \alpha_{\prime\prime} \ldots\ldots$ are factors depending on the adopted periods $p\ p_{\prime}\ p_{\prime\prime} \ldots\ldots$ of the severa terms; so that $\alpha = \frac{360°}{p}$ $\alpha_{\prime} = \frac{360°}{p_{\prime}}$ $\alpha_{\prime\prime} = \frac{360°}{p_{\prime\prime}}$, etc.

Thus to $\alpha = 0.9$, 1.0, 1.2, 1.5 correspond periods of 400, 360, 300 and 240 years respectively.

$r\ r_{\prime}\ r_{\prime\prime} \ldots\ldots$ are parameters and

$c\ c_{\prime}\ c_{\prime\prime} \ldots\ldots$ epochal constants of the several periodic terms.

δ = a constant, representing the mean or normal declination about which the periodic fluctuations take place.

The quantities δ $r\ r_{\prime}\ r_{\prime\prime} \ldots$ $\alpha\ \alpha_{\prime}\ \alpha_{\prime\prime} \ldots$ and $c\ c_{\prime}\ c_{\prime\prime} \ldots$ for any one locality have all to be determined from the observations made there at various times, and their most probable values are to be deduced by application of the method of least squares.

We begin by assuming a suitable value* for the length of the principal period, and the first periodic term of the formula is treated as follows:

*It may be found graphically in the first instance.

Put $\delta = \delta_{,} + x$ where $\delta_{,}$ = an assumed approximate value of δ and x a correction to it; also put

$$r \cos c = y \qquad \text{and} \qquad r \sin c = z,$$

then the conditional equations will take the form

$$0 = \delta_{,} - \mathrm{D} + x + \sin \alpha m \, . \, y + \cos \alpha m \, . \, z + \ldots\ldots\ldots$$

from which the numerical values of x y z are to be deduced in the usual way by means of normal equations. To determine the value of α (and similarly of $\alpha_{,}$ $\alpha_{,,}$ . . .) the computation is repeated three times (or more if necessary) using the slightly changed values $\alpha + \Delta\alpha$ and $\alpha - \Delta\alpha$, from which that particular value of α is found and finally retained which renders the sum of the squares of the differences of observed and computed declinations a minimum. In some cases where certain observations were evidently less trustworthy than others, and which nevertheless could not be dispensed with owing to the small number of observations, or on account of their special value with reference to time, special weights were assigned; generally each observation received the weight unity, a few imperfect observations the weight one-half. In these cases the conditional equations were multiplied by the square root of their respective weight. Of observations evidently grossly in error no notice whatever was taken. In finally selecting what seemed to be the best expression for the secular change at a station, I have also occasionally been guided by the accord of the various values entering into the equation when compared with corresponding values in the equations for surrounding stations. When applying Cauchy's method of interpolation the form

$$\mathrm{D} = \delta + r \cos c \, . \, \sin m\alpha + r \sin c \, . \, \cos m\alpha + \ldots$$

was found more convenient in use. This method was employed for establishing such second or third periodic terms as appeared demanded by the observations, but only a few of these could be determined and they generally failed on account of insufficiency in number of data or for want of sufficient accuracy in the observations.

The annual change v of the magnetic declination due to the secular motion, positive when increasing west (or decreasing east) and negative when in the opposite direction; also the epoch of minimum west declination (or of maximum east); also the amount of the declination at this epoch and the apparent probable error of an observation—are found as follows:

Differentiating the expression for D, we have

$$d\mathrm{D} = r\alpha \cos (\alpha m + c) \, dm + r_{,}\alpha_{,} \cos (\alpha_{,}m + c_{,}) \, dm + \ldots\ldots$$

hence for any time t and for minutes of arc,

$$v = 60 \sin 1^{\circ} \left[r\alpha \cos (\alpha m + c) + r_{,}\alpha_{,} \cos (\alpha_{,}m + c_{,}) + \ldots \right]$$

Maxima and minima are deduced from the equation:

$$0 = r\alpha \cos (\alpha m + c) + r_{,}\alpha_{,} \cos (\alpha_{,}m + c_{,}) + \ldots\ldots$$

from which expression m can be found.

The apparent probable error e_0 of an observation is deduced from the differences Δ of the n observed and computed declinations by the formula $e_0 = \sqrt{\dfrac{0.455 \, \Sigma \Delta^2}{n - n_{,}}}$, where Σ indicates summation and $n_{,}$ equals the number of unknown quantities in the expression for D, determined from the observations themselves; when weights w enter, we substitute $w\Delta^2$ for Δ^2 and then obtain the probable error of an observation of unit weight. The greater part of this apparent probable error is due to the fact that the observations collected at any one place were not generally made at precisely the same spot, thus admitting the effect of possible local irregularities in the distribution of magnetism in addition to the ordinary observing errors. In other cases the observations evidently were not corrected for diurnal variation, and the hour of the day of observation not being known, the received imperfect value had to be accepted.

There are some stations where from want of a sufficient number of observations, or from shortness of interval between the first and last observation, no period of the secular variation could be made out. In such cases the *annual change* due to the secular motion may be expressed by means of an exponential function, thus:

$$\mathrm{D} = d_0 + y\,(t - t_0) + z\,(t - t_0)^2 + \ldots .$$

where d_0 = magnetic declination at epoch t_0. I adopt, as in the preceding formulæ, $t_0 = 1850.0$ and put $d_0 = \delta + x$, where δ = an approximate value of d_0 and x a correction to it to be determined, as well as y and z &c., from the observations themselves. For this purpose we have conditional equations of the form

$$0 = \delta - D + x + ym + zm^2 + \ldots.$$

which equations are to be treated, as customary, by the method of least squares.

D = resulting magnetic declination $\left\{ \begin{array}{l} + \text{ when W} \\ - \text{ when E} \end{array} \right\}$ for the time t

a = annual change $= y + 2z\ (t - t_0) = y + 2z.m$; also

T = time of maximum declination $= t_0 - \dfrac{y}{2z}$

In case the change of declination can be represented by a straight line, we have

$D = d_0 + a\ (t - t_0)$ and the conditional equation $0 = d_0 - D + a\,(t - t_0)$

where d_0 = mean of all observed declinations and t_0 = mean of corresponding times.

The principal uncertainty in the investigation thus arises partly from large observing or instrumental errors in the older observations made with ordinary compasses or with rude instruments generally, and partly, in modern observations, since the introduction of more refined instruments (the magnetometer with collimator magnet and theodolite) from change of local position and imperfect elimination of irregular variations from the normal direction of the magnet. From the extended use of iron and the rapid growth of cities, it is difficult to select and preserve at such places a suitable locality for use at future times. Accurate investigations of the secular variation can only be made at permanent magnetic observatories or in localities not liable to disturbing influences.

In applying at present a periodic function for representing the secular variation, it should be understood that this *does not necessarily* imply that the phenomenon is a periodic one, or has a period of the length assigned, or that it must exhibit a second or more periods of like character to the first, or even that a first period will be completed without change of law.* The aim is simply to represent by a suitable and comprehensive formula the changes which are observed in the direction of the resultant horizontal magnetic force from year to year and during centuries, and to provide the means for the further study of the phenomenon as well as for predicting, at least for a few years in advance, the probable direction of the needle as required for use on our hydrographic charts.

The process is thus one of a tentative character and the formulæ are empirical. Employing a formula of interpolation capable of representing the phenomenon as far as observed, it would manifestly be unsafe to extend the numerical results much beyond the limits of observation. They are here given within proper and safe limits and should not be transcended unless it should be found that the results are sustained by additional observations.

COLLECTION OF MAGNETIC DECLINATIONS FOR THE DISCUSSION OF THE SECULAR VARIATION.

The collection of the material is presented first, the stations being arranged in approximately geographical order, beginning in the northeast, passing to the south and west and ending in the northwest. This approximates to an arrangement proceeding from the greatest western to the greatest eastern declination. For each locality the observed declinations are given in chronological order, together with such notes and references respecting observer, place, publication, &c., as could be supplied. The stations here given are the only ones, as far as known, at present suitable for a discussion of the secular variation, but it is expected that future accumulation and collection of data will render the character of the work more comprehensive and reliable than it can now be made.

*If we suppose for the moment that the secular variation consists simply of a swing about a mean position, the deflecting force being a maximum at the times of elongation and zero for the epoch midway between, we may obtain some rough evaluation of the magnitude of the horizontal deflecting force when greatest. Thus, at Philadelphia the half-amplitude or the secular deflection either way from the normal equals nearly 3°.3 and the last extreme deflection happened about 1807. At that time, then, the deflecting force corresponded to $\frac{3.3}{57.3} = \frac{1}{17}$ nearly of the normal horizontal force acting in the plane of the meridian. This deflecting force is very much greater than the deflecting force which produces the daily solar variation, the latter being at most, at Philadelphia, for an average amplitude of 8'.0 equal to $\frac{4.0}{3437.7} = \frac{1}{860}$ nearly of the same normal horizontal force.

COLLECTION OF MAGNETIC DECLINATIONS, OBSERVED AT VARIOUS PLACES IN THE UNITED STATES AND AT SOME FOREIGN STATIONS, FROM THE EARLIEST TO THE PRESENT TIME, AND FOUND SUITABLE FOR THE INVESTIGATION OF THE SECULAR VARIATION.

PARIS, FRANCE.*

$\phi = 48° 50'.2$ $\lambda = -2° 20'.2$

(Paris observatory.)

		°	′		
1†	1541	7		E.	Bellarmatus.
2	1550	8			Orontius Finæus (Oronce Finné).
3	1580	11	30		Sennertus.
4	1603	8	45		Nantonnier.
5	1610	8	0		Nantonnier.
6	1630	4	30		Petit.
7	1642	2	30		Petit.
8	1659 and 1660	1	30		
9	1664	0	40	E.	Picard.
10	1666 and 1667	0	08	W.	
11	1670	1	30		
12	1680–81–82–83–84	3	08		Picard and La Hire.
13	1685–86–87–88–89	4	52		La Hire and Cassini.
14	1691–92–93–95–96–97–98	6	37		La Hire and Cassini; includes mean of 2 values of 1698.
15	1699, 1700–1–2–3–4–5–6–7	9	00		La Hire and Cassini; includes mean of 2 values each for 1700–1–2–3–4, and of 3 values for 1705.
16	1708–9–10–11–12–13–14–15–16	11	11		La Hire and Cassini; 1 value for 1715, 3 for 1716 and 2 values each for other years.
17	1717–18–19–20–21–22–23–24–25	12	52		Cassini, La Hire, and Maraldi; 2 values for 1717–18–21–22–23, 3 for 1725 and 1 for 1719–20–24.
18	1726–27–28–29–30–31–32–33–34	14	37		Maraldi and Buache; 2 values for 1734.
19	1735–36–37–38–39–40–41–42–43	15	23		Maraldi and Cassini; 2 values for 1735–36–38–40–42 each.
20	1744–45–46–47–48–49–50–51–52	16	37		Fouchy.
21	1753–54–55–57–58–59–60	17	49		Maraldi.
22	1765	19	00		
23	1770–71–72–73–74	20	01		Maraldi and Le Monnier; 2 values each for 1772–73–74.
24	1777–78–79–80–81	20	40		Le Monnier; 2 values for 1778, 6 for 1779, 46 for 1780 and 12 for 1781.
25	1782–83–84–85–86	21	25		Le Monnier; 3 values for 1782–83 each and 2 for 1784–86 each.
26	1789–90–91–92–93	22	18		Le Monnier; 2 values for 1790–91 each.
27	1798–99–1800–1	22	14		Le Monnier; 2 values for 1799.
28	1802–3–4	21	58		Le Monnier, Bouvard, and Cotte; 3 values for 1802.
29	1805	22	05		Cotte; E. Walker in "Terrestrial and Cosmical Magnetism," 1866.
30†	1807	22	34		Bouvard.
31	1810, March 13, 1 p. m	22	16		Mean 22° 24′.5; same corrected for diurnal variation, 22° 20′, epoch 1812.2
	1811, October 15, noon	22	25		
	1812, October 9, 2½ p. m	22	29		
	1813, October 30, noon	22	28		
32	1814, August 10, noon	22	34		Mean 22° 26′.0; same corrected for diurnal variation, 22° 22′, epoch 1816.5
	1816, October 12, 3 p. m	22	25		
	1817, February 10, 0½ p. m	22	19		
33	1823	22	23		Mean 22° 15′ for 1827.2; A. Guyot in Johnson's Universal Cyclopædia, Art. Earth, New York, 1876.
	1827	22	20		
	1828	22	05		
	1829	22	12		
34	1835.5	22	04		Arago; Gen. Sir E. Sabine, Phil. Trans. Roy. Soc., vol. 162, part ii, 1872, $\phi = 48° 53'$, $\lambda = -2° 20'$.
35	1838, February	21	38		Darondeau; Phil. Trans. Roy. Soc., 1849, part ii.
36	1842.5	21	29		Lamont; Gen. Sir E. Sabine in Phil. Trans. Roy. Soc., vol. 162, part ii, 1872.
37	1858, January 1	19	36.3		Rev. S. J. Perry; Magnetic Survey of the East of France; Phil. Trans. Roy. Soc., vol. 162, 1872, London, 1873.
38	1865	18	44		Encyclopædia Britannica; 9th ed., 1877, Art. Compass.
39	1869, September 1	17	08.4		Rev. S. J. Perry; Mag. Survey of the East of France.
40	1875, July	17	21		Jordan's Vermessungskunde, vol. 1, Stuttgart, 1877.
41	1879, January 1	16	56	W.	Annuaire pour l'an 1882, Paris.

* This station has been included in our discussion as a means of showing the connection of the laws of secular variation as observed in Europe and North America.

† All the values between 1541 and 1807, inclusive, except for 1805, were taken from the Encyclopædia of Experimental Philosophy (part of the Ency. Metropolitana), London, 1848. Art. Magnetism, by Peter Barlow. The values were combined by me into suitable groups and their means were separately taken, as indicated above.—SCH. The values Nos. 31, 32 were taken from Walker's "Terrestrial and Cosmical Magnetism," Cambridge, England, 1866. These observations are by Arago.

Collection of Magnetic Declinations, etc.—Continued.

HALIFAX, NOVA SCOTIA.*

$\phi = 44° 39'.6$ $\lambda = 63° 35'.3$ W. of Gr.

(Naval-yard observatory.)

		°	′		
1	1700	13		W.	According to chart by Edm. Halley: Tabula Nautica; Variationum Magneticarum index juxta observationes anno 1700. [Greenwich astronomical observations, 1869.]
2	1756	12	50		From MS. map by Charles Morris, assistant surveyor.
3	1775	13	35		Des Barres' Sailing Directions.
4	1798	16	30		Plan published by Thomas Backhouse.
5	1818 (about)	17	28		Remark-book of J. Napier, master R. N., as given by Anthony Lockwood, esq.
6	1821, June and November	17	36		Remark-book of J. Napier, master R. N., as observed by himself, viz, in June, 17° 38′.2; in November, 17° 33′.5.
7	1852–53	18	10		Captain Bayfield, mag. survey.
8	1852–53	18	51		Remark-book of J. Hill, master R. N., viz, August, 1852, 18° 46′; September, 1852, 19° 21′; August, 1853, 18° 25′.
9	1860, July 22	19	55		Captain Orlebar, R. N.
10	1866, April	21	05.6		Halifax dock-yard, in $\phi = 44° 40'$, $\lambda = 63° 25'$ W.; declination, April 1, 9 a. m., 20°55′.0; April 3, 3 p. m., 21° 16′.3
11	1879, September 8–10	20	43.3	W.	J. B. Baylor, U. S. Coast and Geodetic Survey. In southeast end of Dock Yard.

* For the collection and communication of the observed values, Nos. 2 to 10, at Halifax, Nova Scotia, the Coast and Geodetic Survey is indebted to Staff-Commander Fred. John Evans, R. N. (Hydrographer to the Admiralty). Letters dated January 5, 1866, and April 26, 1867. According to Champlain's observations in this region, the declination at Halifax would appear to have been about 16⅔° west for 1604 to 1612. Our formula gives 19° west. Champlain's observations are not certain within ± 4 or 5°.

QUEBEC, CANADA.

$\phi = 46° 48'.4$ $\lambda = 71° 14'.5$ W. of Gr.

(Wolfe's Monument.)

		°	′		
1	1642	16		W.	Padre Bressani; Hansteen's Magnetismus der Erde, 1819; also Trans.† of the Lit. and Hist. Soc. of Quebec, 1865. Hansteen's date, 1649, changed to 1642, according to President J. Langton, Art. x of Trans.
2	1686	15	30		De Hayes; Hansteen's Mag. der Erde, 1819.
3	1700	16			Edm. Halley's Isogonic Chart for 1700, Greenwich Observations for 1869.
4	1785	12	35		Surveyor-General Holland; E. T. Fletcher, in Trans.† of the Lit. and Hist. Soc. of Quebec, 1865, Art. ix.
5	1789, June 30	11	45		Louis Perrault, P. L. S.; reference as above.
6	1791, June 22	13	00		Pierre Beaupré, P. L. S.; reference as above.
7	1792, March 24	12	15		J. B. Demers, P. L. S.; reference as above.
	1792, May 9	13	09		A. Dezery, P. L. S.; reference as above.
	1792, May 16	12	00		Ch. Turgeon, P. L. S.; reference as above.
	1792, May 16	12	15		Fr. Legendre, P. L. S.; reference as above.
8	1793	12	05		Surveyor-General Holland; reference as above.
	1793, November 19	13	00		J. C. Antill, P. L. S.; reference as above.
9	1805, April	11	35		Reg. A, folio 117, Dept. of Crown Lands; reference as above.
10	1810	11	00		Becquerel's Traité du Magnétisme, Paris, 1846.
	1810, June 5	12	15		Reg. A, folio 131; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
11	1811, June	12	15		Reg. A, folio 143; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
12	1814	11	50		Kent; Becquerel's Traité du Magnétisme, Paris, 1846.
13	1820, October 2	12	30		Bourdages, P. L. S.; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
	1820, November	12	35		Livingstone, P. L. S.; reference as above.
14	1821, August 25	12	15		Jno. McNaughten, P. L. S.; reference as above.
	1821, September	13	00		A. Cattanach, P. L. S.; reference as above.
	1821, September	13	00		W. Ware, P. L. S.; reference as above.
	1821, November 28	13	20		E. Tetu, P. L. S.; reference as above.
15	1822, January 21	13	00		Jos. Hamel, P. L. S.; reference as above.
	1822, January 21	13	00		Ph. Verrault, P. L. S.; reference as above.
	1822, April 26	13	00		P. J. Bureau, P. L. S.; reference as above.
	1822, May	13	00		Reg. A, folio 162½; reference as above.
16	1823, March 26	13	00		N. Le François, P. L. S.; reference as above.
	1823, May 12	13	00		D. S. Ballantyne, P. L. S.; reference as above.
	1823, October 3	13	00		Jos. Gamahe, P. L. S.; reference as above.
	1823, October 23	13	00		A. Bochet, P. L. S.; reference as above.
	1823, November 14	13	00	W.	L. Dorval, P. L. S.; reference as above.

† I am indebted to Mr. Marcus Baker, of the Computing Division C. and G. S., for pointing out and procuring this volume for me.

Collection of Magnetic Declinations, etc.—Continued.

QUEBEC, CANADA—Continued.

		°	′		
17	1824, March 2	12	40	W.	A. Cattanach, P. L. S.; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
18	1831	13	38		Captain Bayfield; Becquerel's Traité du Magnétisme, Paris, 1846.
	1831, July 20	13	10		Thos. Carrol, P. L. S.; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
	1831, autumn	13	00		Jos. Hamel, P. L. S.; reference as above.
	1831, September 6	14	00		H. Corey, P. L. S.; reference as above.
	1831, December 10	13	12		John Newman, P. L. S.; reference as above.
19	1832, May	13	00		Reg. B, fol. 36; reference as above.
20	1833, May	12	30		Reg. B, fol. 43; reference as above.
	1833, July	13	00		Reg. B, fol. 43; reference as above.
21	1834	14	14		Capt. Bayfield; Trans. Roy. Soc., June, 1872, Gen. Sir E. Sabine, Contributions to Terr. Mag., No. xiii.
	1834, March 10	13	00		Reg. A, fol. 197; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
	1834	13	00		Reg. B, fol. 61; reference as above.
	1834, July	13	00		Reg. B, fol. 69; reference as above.
22	1835, December	13	10		Reg. B, fol. 85; reference as above.
23	1838 and 1839	13	00		Reg. B, fol. 66; reference as above.
	1839, May	13	30		Reg. B, fol. 144; reference as above.
	1839	13	35		Reg. B, fol. 154; reference as above.
24	1840, May 20	13	50		R. M. Moore, P. L. S.; reference as above.
	1840, September 14	13	35		Procès-Verbal, by Jos. Bouchette, D. S. G.; reference as above.
25	1842, December 7	13	50		Reg. B, fol. 281, Anse des Meres; reference as above.
	1842	14	12		Capt. Lefroy, R. E., Phil. Trans. Roy. Soc., 1849, part ii.
26	1846	14	32		Reg B, fol. 318, La Canardière; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
27	1847, September 17	15	30		Reg. B, fol. 316; reference as above.
	1847, September 20	14	45		Reg. B, fol. 262; reference as above.
	1847, October 13	13	40		Reg. B, fol. 269; reference as above.
28	1848, February	15	15		Reg. B, fol. 277; reference as above.
	1848, June 28	14	00		Reg. B, fol. 299; reference as above.
	1848, October	14	30		N. Le François, P. L. S., field-book C, 50; reference as above.
29	1849, March 8	15	30		Reg. B, fol. 316; reference as above.
	1849, July 8	15	15		Reg. C, fol. 5; reference as above.
30	1850, April	15	15		Reg. C, fol. 13; reference as above.
31	1851, autumn	15	00		Reg. C, fol. 33; reference as above.
32	1853, January 19	15	30		Reg. B, fol. 320; reference as above.
33	1858, October 8	15	34		Capt. Orlebar, R. N.; communicated by Capt. F. J. Evans, Hydrographic Department, Admiralty, London.
34	1859, July 19	16	17		C. A. Schott, assistant U. S. Coast Survey, C. S. Report, 1859, p. 296, station near Wolfe's Monument.
35	1860, October 12	16	28		Capt. Orlebar, R. N.; communicated by Capt. F. J. Evans, Hyd. Dept. Admiralty.
36	1865	16	40		E. T. Fletcher, surveyor to Department of Crown Lands.
37	1879, September 16, 19	17	13.7	W.	J. B. Baylor, U. S. Coast and Geodetic Survey; station of 1859.

NOTE: Observations of the same year are united into a mean value for that year.

MONTREAL, CANADA.

$\phi = 45° 30'.5$ $\lambda = 73° 34'.9$ W. of Gr.

(McGill University.)

		°	′		
1	1749	10	38	W.	M. Gillion } V. Colvin, Sup't Adirondack survey, N. Y., 7th annual report, Albany, 1880, p. 492.
2	1785	8	24		Holland, Surv. Gen. of Canada } V. Colvin, Sup't Adirondack survey, N. Y., 7th annual report, Albany, 1880, p. 492.
3	1793, July 26	8	15		Jer. McCarthey, Trans. Lit. and Hist. Soc. of Quebec, session of 1864-'65, new series, Quebec, 1865, p. 3.
4	1814	7	45		Becquerel's Traité du Magnétisme, Paris, 1846.
5	1834	8	00		Capt. Bayfield; Phil. Trans. Roy. Soc., 1849, Gen. Sabine's Contributions, No. ix; in $\phi = 45° 32'$, $\lambda = 73° 34'$.
6	1835	9	50		Reference: 7th annual report Adirondack survey, N. Y.; V. Colvin, Sup't, Albany, 1880, p. 492.
7	1842, August	8	58		Capt. Lefroy, R. A., Coast Survey Report, 1855, p. 304.
8	1859, July 20	12	21		C. A. Schott, Assistant Coast Survey, MS. in Coast Survey Archives, grounds of McGill University, in $\phi = 45° 30'.5$, $\lambda = 73° 34'.9$
9	1879, September 25	13	40′.5	W.	J. B. Baylor, U. S. Coast and Geodetic Survey, grounds of McGill University.

Collection of Magnetic Declinations, etc.—Continued.

YORK FACTORY, HUDSON BAY.

$\phi = 57° 00'$ $\lambda = 92° 26'$ W. of Gr.

		°	′		
1	1725	19		W.	Capt. Middleton; Hansteen's Magnetismus der Erde, 1819; also Gen. Sir E. Sabine, Proc. of the Roy. Soc., 1858.
2	1787	5		W.	Hansteen's map; references as above.
3	1819, September	6	00	E.	Sir J. Franklin, in $\phi = 57° 00'$, $\lambda = 92° 26'$; Gen. Sir E. Sabine, Proc. Roy. Soc., 1858, and Cont. to Terr. Mag., No. xiii, Phil. Trans. Roy. Soc., 1872.
4	1843, July	9	25		Capt. Lefroy, R.A.; references as above.
5	1857, August	7	37		Capt. Blakiston, R.A.; references as above.
6	1878	5	30		Alfred R. C. Selwyn, director Geological Survey of Canada; report of 1878-'79, Appendix VII, Montreal, 1880, S.W. side of fort. In 1878 he found only 5° 30′ at the N. E. side, but there appeared to be local attraction. [Used – 6° 30′ for the present.—SCH.]
	1879	7	00	E.	

EASTPORT, ME.

$\phi = 44° 54'.4$ $\lambda = 66° 59'.2$ W. of Gr.

(Fort Sullivan.)

		°	′			
	1604 to 1612	17	32	W.	Champlain; Douchet's Island, St. Croix River. [Not used.]	
	1700	13			According to Edm. Halley's isogonic chart of 1700.* [Not used.]	
1	1775	12	40		At Grand Manan Island; J. F. W. Des Barres' Atlantic Neptune, London, 1781.	
	1797	12	19		From a chart; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838; at the mouth of St. Croix, in $\phi = 45° 05'$, $\lambda = 67° 12'$; reduction to Eastport about – 5′. [Not reliable.]	
	1857, September 16-19	15	21.1		G. W. Dean, assistant Coast Survey; at Calais, in $\phi = 45° 11'.1$, $\lambda = 67° 16'.8$; Coast Survey Report for 1858, p. 191; reduction to Eastport – 12′. [Not used; probable local deflection.]	
2	1860, August to December	17	57.1		G. B. Vose, observer for United States Coast Survey	Coast Survey Report for 1865, Appendix No. 18; all observations made at Fort Sullivan.
3	1861, January to December	17	59.2		G. B. Vose and S. Walker, observers for United States Coast Survey.	
4	1862, January to December	18	00.6		S. Walker, R. H. Talcott, E. Goodfellow, observers for United States Coast Survey.	
5	1863, January to December	18	02.3		E. Goodfellow, assistant Coast Survey	
6	1864, January to July, inclusive	18	03.7		E. Goodfellow, A. T. Mosman, and H. W. Richardson, observers for United States Coast Survey.	
7	1865, July 22, 23, 24, 25	18	06.1		H. W. Richardson, observer for United States Coast Survey.	
8	1873, September 2, 3	18	56.0		Dr. T. C. Hilgard, observer for United States Coast Survey; at Fort Sullivan; MS. in Coast Survey archives.	
9	1879, August 27, 28	19	07.8	W.	J. B. Baylor, United States Coast and Geodetic Survey, station of 1860; parade ground of Fort Sullivan, in $\phi = 44° 54'.4$, $\lambda = 66° 59'.2$	

*Tabula Nautica. Variationum magneticarum index juxta observationes anno 1700 (Greenwich astronomical observations of 1869).

PORTLAND, ME.

$\phi = 43° 38'.8$ $\lambda = 70° 16'.6$ W. of Gr.

(Bramhall Hill.)

		°	′		
1	1763	7	45	W.	Prof. John Winthrop, at Falmouth, in $\phi = 43° 39'$, $\lambda = 70° 19'$; Sill. Jour., vol. xvi, 1829; see also Prof. E. Loomis' remarks on the Winthrop Table in Sill. Jour., vol. xxxiv, 1838.
2	1775	8	30		J. F. W. Des Barres' Atlantic Neptune, London, 1781.
3	1845, June 4	11	28.3		Dr. J. Locke, in $\phi = 43° 41'$, $\lambda = 70° 20'$; Smithsonian Contributions to Knowledge, vol. iii, 1852.
4	1851, August 18, 20	11	41.1		J. E. Hilgard, assistant Coast Survey, at Bramhall Hill, in $\phi = 43° 38'.8$, $\lambda = 70° 16'.6$; Coast Survey Report for 1854, p.* 143.
5	1859, July 15	12	20		C. A. Schott, assistant Coast Survey, at Bramhall Hill; Coast Survey Report of 1859, p. 296.
	1863, July 6	12	18.1		C. A. Schott, assistant Coast Survey, at Mount Joy Observatory, in $\phi = 43° 39'.9$ $\lambda = 70° 14'.9$; Coast Survey Report of 1863, p. 204. [Not used.]
6	1863, July 15	12	28.2		C. A. Schott, assistant Coast Survey, at Bramhall Hill, in $\phi = 43° 38'.8$, $\lambda = 70° 16'.6$; Coast Survey Report of 1863, p. 204.
7	1864, August to December	12	43.7		Prof. H. W. Richardson, observer for United States Coast Survey, at Bramhall Hill; monthly determinations on four days, about the middle of each month; MS. in Coast Survey archives.
8	1865, January to December	12	42.3		
9	1866, January to March, inclusive	12	42.9		
10	1873, September 8, 9, 11	12	43.6	W.	Dr. T. C. Hilgard, observer for United States Coast Survey, at Mount Joy Observatory, two stations; MS. in Coast Survey archives; to refer to Bramhall Hill, add 10′.

Collection of Magnetic Declinations, etc.—Continued.

BURLINGTON, VT.

$\phi=44° 28'.2$ $\lambda=73° 12'.3$ W. of Gr.

(Coast Survey astronomical station.)

		° ′	
1	1793	7 38 W.	Dr. Williams; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; in $\phi=44°$ $28'$, $\lambda=73°$ $14'$.
2	1805	6 12	J. Johnson, in Thompson's History of Vermont; from repeated comparisons. Declination believed by him to have been the minimum.
3	1818	7 30	J. Johnson } Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; in $\phi=44° 28'$, $\lambda=73° 14'$.
4	1822	7 42	J. Johnson
5	1826	7 36	Prof. G. W. Benedict; Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840; in $\phi=44° 27'$, $\lambda=73° 10'$.
6	1830	8 10	J. Johnson } Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
7	1831	8 15	J. Johnson
8	1832	8 25	J. Johnson
9	1834	8 50	J. Johnson
10	1837	9* 45	Prof. Benedict; Thompson's History of Vermont.
	1840	9 42	J. Johnson; Thompson's History of Vermont. [Not used.]
11	1845, June 26	9 22	Dr. J. Locke, in $\phi=44° 27'$, $\lambda=73° 10'$; Smithsonian Contributions to Knowledge, vol. iii, 1852.
12	1855, August 28	9 57.1	C. A. Schott, assistant Coast Survey, in $\phi=44° 29'.3$, $\lambda=73° 13'.4$, at encampment flag-staff, near shore of the lake; Coast Survey Report of 1855, p. 337.
13	1873, October 14, 15	11 19.0 W.	Dr. T. C. Hilgard, observer for United States Coast Survey; MS. in Coast Survey archives.

* Supposed misprint for 8°.

RUTLAND, VT.

$\phi=43° 36'.5$ $\lambda=72° 55'.5$ W. of Gr.

(Post-office.)

		° ′	
1	1789, April	7 03 W.	} Dr. Williams; Sill. Jour., vol. xvi, 1829.
2	1810, May	6 04	
3	1811, September	6 01	
4	1859, July 21	9 49	C. A. Schott, assistant Coast Survey; near new post-office; Coast Survey Report for 1859, p. 296.
5	1873, October 17, 18	10 40.2	Dr. T. C. Hilgard, observer for United States Coast Survey; MS. in Coast Survey archives.
6	1879, October 14, 15	11 09.0 W.	J. B. Baylor, U. S. Coast and Geodetic Survey, station of 1873; north and west of post-office, $\phi=43° 36'.5$, $\lambda=72° 55'.5$

PORTSMOUTH, N. H.

$\phi=43° 04'.2$ $\lambda=70° 42'.5$ W. of Gr.

(New Castle Lighthouse.)

		° ′	
1	1771	7 46 W.	Holland, at Kittery, Me.; in $\phi=43° 06'$, $\lambda=70° 45'$, Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
	1771	7 48	Holland, in $\phi=43° 05'$, $\lambda=70° 45'$; reference as above. [Not used.]
2	1775	7 45	J. F. W. Des Barres' Atlantic Neptune, London, 1781.
3	1844-5	9 47	Major Graham at Boiling Rock Boundary Survey. Gen. Sir E. Sabine, in Phil. Trans. Roy. Soc., 1872, $\phi=43° 05'$, $\lambda=70° 45$.
4	1850, August 28, September 2	10 30.2	J. E. Hilgard, assistant Coast Survey, at Kittery Point, Me.; Coast Survey Report of 1854, p. *143.
5	1859, July 14	11 15	C. A. Schott, assistant Coast Survey, at Kittery Point, Me.; Coast Survey Report of 1859, p. 296.
6	1879, August 13, 14	12 31.3 W.	J. B. Baylor, U. S. Coast and Geodetic Survey, station of 1850 and 1859, in $\phi=43° 04'.8$, $\lambda=70° 43'.0$

Collection of Magnetic Declinations, etc.—Continued.

NEWBURYPORT, MASS.

$\phi = 42° 48'.4$ $\lambda = 70° 49'.0$ W. of Gr.

(Plum Island lights.)

		° ′	
1	1775	6 45 W.	J. F. W. Des Barres' Atlantic Neptune, London, 1781; north of Cape Ann, opposite Newburyport.
2	1781	7 18	Dr. Williams in $\phi = 42° 48'$, $\lambda = 70° 52'$; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
3	1850, September 18–20	10 05.6	J. E. Hilgard, assistant Coast Survey, on Plum Island, in $\phi = 42° 48'.0$, $\lambda = 70° 48'.8$, Coast Survey Report for 1854, p. *143.
4	1859, July 13	10 58 W.	C. A. Schott, assistant Coast Survey, same position as above; Coast Survey Report for 1859, p. 296.

SALEM, MASS.**

$\phi = 42° 31'.9$ $\lambda = 70° 52'.5$ W. of Gr.

(Fort Lee.)

		° ′	
1	1781, August	7 02 W.	President Willard, at Beverly, in $\phi = 42° 33'$, $\lambda = 70° 54'$, mean of seven observations; Sill. Jour., vol. xxvi, 1829; reduction to Salem—8′.
2	1805, November	5 57	Dr. Bowditch, in Summer street, Salem, from 115 observations.
	1808, June	5 20	Dr. Bowditch, one-eighth of a mile south of above place, from 112 observations. [Not used.]
3	1810, April	5 47.7 5 13.4	Dr. Bowditch, about one-fourth of a mile east of the place of 1805. [Second value not used.]
3	1810, April, to 1811, May	6 22.6	Dr. Bowditch, result by a third needle from 5125 observations of monthly values. Mean of two needles, +6°.09 in 1810.5 Reference to Nos. 2, 3, Sill. Jour., vol. xvi, 1829.
4	1849, August 20	10 14.5	Prof. G. W. Keely, observer for United States Coast Survey, at Fort Lee; Coast Survey Report for 1854, p. *143.
5	1855, August 25	10 49.7	C. A. Schott, assistant Coast Survey, at Fort Lee; Coast Survey Report for 1855, p. 337.
6	1877.5	11 30 W.	I. K. Harris, communicated in a letter to Superintendent, dated Lynn, Feb. 18, 1878.

** The vicinity of Salem is subject to local magnetic deflections, they have been traced as far as Cape Ann.

BOSTON, MASS.

$\phi = 42° 21'.5$ $\lambda = 71° 03'.8$ W. of Gr.

(State-house.)

		°	
1	1700	10 W.	Prof. J. Winthrop's table, ‡Sill. Jour., vol. xvi, 1829 (also Mem. Am. Acad., vol. ii, new series, Cambridge, 1846); also Coast Survey Report for 1855, p. 316.†
2	1708	9	Mathews, observer, Sill. Jour. for 1829, Dr. N. Bowditch; also Encyc. Met., 1848.
3	1741	7 30	Mathews; Encyc. Met., 1848.
4	1875-76	7 40	Des Barres' Atlantic Neptune, London, 1781.
5	1782	7 00	Sill. Jour. for 1829, Dr. N. Bowditch; see also first vol. Mem. Am. Acad.
6	1793	6 30	Mean of 1644 observations; Mem. Am. Acad., new series, Cambridge, 1846.
7	1807	6 05	Communicated by W. Rotch, letter dated Fall River, February 17, 1874.
8	1839	9 06	W. C. Bond, at Dorchester, in $\phi = 42° 19'$, $\lambda = 71° 04'$; Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840.
9	1746, September 6–8	9 31.4	Lieut. T. J. Lee, assistant Coast Survey, at Dorchester Heights, South Boston, in $\phi = 42° 20'.0$, $\lambda = 71° 02'.5$; Coast Survey Report for 1854, p. *143.
10	1855, August 24	10 13.7	C. A. Schott, assistant Coast Survey, in South Boston, locality as above; Coast Survey Report of 1855, p. 337.
11	1872, September 28, 30, October 1.	11 15.2	A. H. Scott, United States Coast Survey, locality as above; MS. in Coast Survey archives.
12	1877.5	11 36 W.	At meridian line on Boston Common, from records at the City Hall, communicated by I. K. Harris, February 18, 1878.

‡ In this table the observed and interpolated values were pointed out by Prof. E. Loomis; no notice is taken of the latter values. The table was published in the "Boston Post Boy," July 2, 1764. (Information by J. H. Trumbull.)

† See also Edm. Halley's isogonic chart for the epoch 1700, reproduced by photolithography in the "Greenwich observations of 1869;" "it gives about 10° W. for Boston.

Collection of Magnetic Declinations, etc.—Continued.

CAMBRIDGE, MASS.

$\phi=42° 22'.9$ $\lambda=71° 07'.7$ W. of Gr.

(Harvard College observatory.)

		° ′	
1	1708	9 W.	Brattle, observer; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838 (same reference for Nos. 2,3,4,7,and 9); Mem. Am. Acad., vol. ii, new series, Cambridge, 1846; also Encyc. Met., 1848; also Coast Survey Report for 1855, p. 317.
2	1742	8	Prof. J. Winthrop's table ¶ Sill. Jour., vol. xvi, 1829; also Mem. Am. Acad., vol. ii, new series, Cambridge, 1846.
3	1757	7 20	Prof. J. Winthrop; reference as above.
4	1761	7 14	Dr. Williams, Mem. Am. Acad. vol. ii, 1846.
5	1763	7 00	Prof. J. Winthrop; Sill. Jour., vol. xvi, 1829.
6	1780	7 02	Dr. Williams; Encyc. Met., 1848.
7	1782	6 45	Dr. Williams; Encyc. Met., 1848; in Mem. Am. Acad., 1846, 6° 46′.
	1782	6 44	Prof. Sewall (mean of extremes 6° 21′ and 7° 08′); Sill. Jour. for 1829. See also first vol. of Mem. Am. Acad.
8	1783	6 52	Dr. Williams; Mem. Am. Acad., 1846; also Encyc. Met., 1848.
9	1788	6 38	Dr. Williams; Mem. Am. Acad., 1846.
10	1810	7 30	Prof. Farrar; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
11	1835	8 51	
12	1837	9 09	Mem. Am. Acad., Cambridge, 1846.
13	1840.4	9 18	W. C. Bond, director Harvard College observatory, observer. Mem. Am. Acad., 1846. See also Phil. Trans. Roy. Soc., 1849.
14	1842.2	9 34.9	Prof. J. Lovering; Mem. Am. Acad., vol. iv, 1850. Half-hourly observations during one year, October, 1841, to October, 1842.
15	1844	9 39	W. C. Bond, director Har. Coll. observatory; MS. communicated by Prof. Lovering.
16	1845, June 2	9 32	Dr. J. Locke, Smithsonian Contributions to Knowledge, vol. iii, 1852.
17	1859, August 9	9 30	Lieut. J. C. Ives, at Har. Coll. observatory; Coast Survey Report for 1856, p. 222.
18	1852	10 08	W. C. Bond, director Har. Coll. observatory. Communicated in a letter by Prof. Lovering (May 29, 1855).
19	1854	10 39	
	1854, May 10	9 46	Lieut. J. C. Ives, at Har. Coll. observatory. [Used mean value for 1854.]
20	1855, May 22, 23	10 54.6	W. C. Bond, director Har. Coll. observatory. Communicated by him, Dec. 24, 1858.
21	1856, May 16	10 50.3	W. C. Bond; reference as above.
	1856, July 17	10 06	Karl Friesach, at Cambridge observatory; Berichte der Kais. Acad. der Wiss., Vienna, vol. 29, 1858. Result corrected for diurnal variation.
22	1859, March	10 48	Lieut. W. P. Smith, U. S. T. E., at Har. Coll. observatory. Communicated by Capt. G. G. Meade, U. S. T. E.
23	1866-67-68	10 41	Prof. J. Winlock, director Har. Coll. observatory; from a large number of observations communicated in November, 1872 [and computed by me.—SCH.]. Mean epoch 1867.5.
24	1879, August 7, 9	11 46.3 W.	J. B. Baylor, U. S. Coast and Geodetic Survey. Grounds of Harvard College observatory, $\phi=42° 22'$, $\lambda=71° 7'.6$

¶ In this table the observed and interpolated values were pointed out by Prof. E. Loomis; no notice is taken of the latter values. The table was published in the "Boston Post Boy," July 2, 1764.

NANTUCKET, MASS.

$\phi=41° 17'.0$ $\lambda=70° 06'.0$ W. of Gr.

(Mitchell's observatory.)

		° ′	
1	1775	6 30 W.	J. F. W. Des Barres' Atlantic Neptune, London, 1781.
	1776	6 30	From a chart, Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. Probably of the same origin as No. 1. [Not used.]
2	1834	8 27	W. Mitchell; in Sill. Jour., vol. xlvi.
3	1838.9	9 02.3	
4	1842, August and September	9 09	
5	1843, September	9 10	
6	1846, July 30, 31	9 14.0	Lieut. T. J. Lee, U. S. T. E., assistant United States Coast Survey; near Mitchell's house. Coast Survey Report of 1854, p. *143.
7	1855, August 22	9 58.3	C. A. Schott, assistant United States Coast Survey; near Nantucket Harbor light, north of Mitchell's house, on beach, in $\phi=41° 17'.5$, $\lambda=70° 06'.0$. Coast Survey Report of 1855, p. 337.
8	1867, May 28, 29, 30	10 19.9	C. O. Boutelle, assistant United States Coast Survey; at Nantucket Cliff, in $\phi=41° 17'.2$, $\lambda=70° 06'.3$ MS. in Coast Survey archives.
9	1879, July 31, August 2	11 27.9 W.	J. B. Baylor, United States Coast and Geodetic Survey; at Cliff Station.

Collection of Magnetic Declinations, etc.—Continued.

PROVIDENCE, R. I.

$\phi = 41° 49'.5$ $\lambda = 71° 24'.1$ W. of Gr.

(Brown University.)

		°	′		
1	1717**	9	36	W.	The declinations between 1717 and 1843 inclusive are given by M. B. Lockwood, civil engineer, and are not stated to be from actual observations or from recorded bearings of a number of permanent objects. Sill. Jour., vol. xliv, 1843. There can be no doubt that this table, like the Winthrop table for Boston and that of Hatboro', Pa., depends in part on interpolation. It is well graduated and unquestionably rests on reliable observations. The values marked "not used" are those which I suppose to be interpolations.—SCH.
	1720	9	28	Not used.	
	1725	9	14	Not used.	
	1730	8	54	Not used.	
	1735	8	39	Not used.	
	1740	8	15	Not used.	
	1745	7	59	Not used.	
	1750	7	40	Not used.	
	1755	7	21	Not used.	
	1760	6	57	Not used.	
	1765	6	43	Not used.	
2	1769**	6	30		
	1775	6	20	Not used.	
	1780	6	16	Not used.	
	1785	6	13	Not used.	
	1790	6	10	Not used.	
	1795	6	10	Not used.	
	1800	6	15	Not used.	
	1805	6	19	Not used.	
	1810	6	24	Not used.	
3	1815**	6	30		
4	1819	6	37		
	1825	6	51	Not used.	
	1830	7	10	Not used.	
5	1835**	7	34		
6	1840	8	25		
7	1841	8	31		
8	1842	8	39		
9	1843	8	46		
10	1855, August 20	9	31.5	W.	C. A. Schott, assistant Coast Survey, grounds east of Brown University, in $\phi = 41° 49'.5$, $\lambda = 71° 24'.1$; Coast Survey Report for 1855, p. 337.

** NOTE.
- Observation of 1717, R. Jackson, on a map of Providence.
- Observation of 1769, Dr. B. West.
- Observation of 1815 by M. Brown, B. Lockwood, and G. Sheldon.
- Observation of 1835; since this time the observations were made more carefully.

HARTFORD, CONN.

$\phi = 41° 45'.9$ $\lambda = 72° 40'.4$ W. of Gr.

(State-house.)

		°	′		
1	1786	5	25	W.	Dr. Williams; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1810	4	46		Asher Miller, at East Hartford, in $\phi = 41° 46'$, $\lambda = 72° 38'$; reference as above.
3	1824	5	45		N. Goodwin; reference as above.
4	1828	6	03		N. Goodwin; reference as above.
4	1829	6	03		N. Goodwin; reference as above.
5	1859, July 27	7	17		C. A. Schott, assistant Coast Survey, in City Park; Coast Survey Report for 1859, p. 296.
6	1867, August 15, 17	7	49.3		C. A. Schott, assistant Coast Survey, in $\phi = 41° 45'.9$, $\lambda = 72° 40'.5$, near the Athenæum; MS. in Coast Survey archives.
	1875 (?)	8	58		T. C. Ellis, C. E. Report Chief of Engineers, 1878, part 1. In $\phi = 41° 45'$, $\lambda = 72° 40'$. [Not used.—SCH.]
7	1879, July 24, 25, 26	8	34.0	W.	J. B. Baylor, United States Coast and Geodetic Survey; station of 1859 in City Park, $\phi = 41° 45'.9$, $\lambda = 72° 40'.5$

Collection of Magnetic Declinations, etc.—Continued.

NEW HAVEN, CONN.

$\phi = 41° 18'.5$ $\lambda = 72° 55'.7$ W. of Gr.

(Yale College.)

		° ′	
1	1761	5 47 W.	President Stiles; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
2	1775	5 25	Prof. Strong; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
3	1780	5 15	President Stiles; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
4	1811	5 10	Nathan Redfield; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
	1818, August	5 45	Hon. De Witt, Sill. Jour., vol. xvi, 1829. [Not used.]
	1819	4 35	Prof. Fisher, of Yale College; Prof. E Loomis' collection of 1838. [Not used. See below.]
5	1819, May. 1820, April	4 25.2	Prof. Fisher, from hourly observations; Sill Jour., vol. xvi, 1829.
6	1828	5 17	N. Goodwin; Prof. E. Loomis' collection, 1838.
7	1834, November. 1835, November.	5 40.6	Prof. E. Loomis, from hourly observations; Sill. Jour., vol. xxx, 1836.
	1835	5 52	Prof. E. Loomis, in his collection of 1838. [Not used.]
8	1836	5 55	E. C. Herrick; Prof. E. Loomis' collection of 1838.
9	1837, November	5 50	E. C. Herrick; Sill. Jour., vol xxxiv, 1838.
10	1840	6 10	E. C. Herrick; Prof. E. Loomis' collection, Sill. Jour., vol. xxxix, 1840.
11	1844	5 45.1	Prof. J. Renwick, observer for United States Coast Survey at Yale College, $\phi = 41° 18'.5$, $\lambda = 72° 55'.7$; Coast Survey records.
12	1845, September 10	6 17.3	Prof. J. Renwick, observer for United States Coast Survey, Pavilion Hotel, south of college, near bay; Coast Survey Report for 1854, p. *143.
	1847, September 25 and October 2.	7 27.2	R. H. Fauntleroy, assistant Coast Survey, at Fort Wooster, in $\phi = 41° 16'.9$, $\lambda = 72° 53'.6$; Coast Survey Report for 1854, p. *143. [Not used.]
	1848, August 21 to 29	7 25.5	J. S. Ruth, subassistant Coast Survey; references as above. [The observations at Fort Wooster are not used; the result is affected by local attraction.]
13	1848, August 10 to 14	6 37.9	J. S. Ruth, United States Coast Survey, Pavilion Hotel; Coast Survey Report for 1854; p. *143.
	1848, August 30, September 1	6 31.9	J. S. Ruth, United States Coast Survey, at Oyster Point, in $\phi = 41° 17'.0$, $\lambda = 72° 55'.7$ (meridian of Yale College); Coast Survey Report for 1854, p. *143.
14	1855, August 17	7 02.7	C. A. Schott, assistant Coast Survey, at Oyster Point, in $\phi = 41° 16'.9$, $\lambda = 72° 55'.8$; Coast Survey Report for 1855, p. 337.
	1871, March	7 22	G. H. Mann, C. E., United States Engineers' survey of harbor of New Haven, on College Green; MS. communication. [Not used.]
15	1872	8 27.5	R. M. Bache, assistant Coast Survey; topographic and hydrographic survey of New Haven Harbor and vicinity, from bearings of trigonometric lines. Hydrographic chart No. 1170.
16	1878, July 18	8 41.2 W.	Dr. T. E. Thorpe, Proceedings of the Roy. Soc., No. 200, 1880. In Professor Silliman's garden, $\phi = 41° 18'.7$, $\lambda = 72° 55'.6$

Collection of Magnetic Declinations, etc.—Continued.

ALBANY, N. Y.

$\phi = 42° 39'.2$ $\lambda = 73° 45'.8$ W. of Gr.

(State Capitol.)

		° ′	
1	1817, October	5 44 W.	De Witt, in $\phi = 42° 39'$, $\lambda = 73° 44'$; Sill. Jour., vol. xvi, 1829.
2	1818, August	5 45	
3	1825, April	6 00	
4	1828	6 14	Geological Report, State of New York, and Sill. Jour., vol. xxxix, 1840.
	1828, September	6 16	
	1828, September	6 18	
5	1830, June	6 18	
6	1831, May	6 25	
	1831	6 32	
	1831, November	6 40	Regents' Report.
7	1834, October	6 40	Regents' Report, and Sill. Jour., vol. xxxiv, 1838.
8	1836, October	6 47	
9	1847, November	7 35	Regents' Report.
10	1855, August 31	7 54.7	C. A. Schott, assistant Coast Survey, at Greenbush, in $\phi = 42° 37'.8$, $\lambda = 73° 44'.3$; Coast Survey Report of 1855, p. 337.
11	1856, September 1	8 39.2	Karl Friesach, in Berichte der Kai. Acad. Vienna, vol. 29, 1858; 8° 35′ when corrected for diurnal variation.
12	1858, May 12–14	8 17.0	G. W. Dean, assistant Coast Survey, at Dudley Observatory, in $\phi = 42° 39'.8$, $\lambda = 73° 44'.9$; Coast Survey Report of 1858, p. 191.
13	1879, October 21, 24	9 51.7 W.	J. B. Baylor, United States Coast and Geodetic Survey; Station of 1858, grounds of Dudley Observatory.

OXFORD, CHENANGO COUNTY, N. Y.

$\phi = 42° 26'.5$ $\lambda = 75° 40'.5$ W. of Gr.

		° ′	
1	1792 to 1795	3 W.	E. B. McCall, surveyor, in a letter to the Superintendent of the Coast Survey, dated December 22, 1858.
2	1817	3	E. B. McCall, in $\phi = 42° 26'.5$, $\lambda = 75° 42'$.
3	1828, July 7	4 30	
4	1834, October 9	3 52	Regents' Report, in $\phi = 42° 28'$, $\lambda = 75° 33'$; also Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
5	1836, October 5	4 09	
6	1837	4 30	Sill. Jour., 1838; also Regents' Report of 1839.
7	1838, July 6	4 30	At Guilford, in $\phi = 42° 24'$, $\lambda = 75° 26'$; Regents' Report; Sill. Jour., 1838; when referred to Oxford, 4° 27′ W.
8	1849, November 27	5 11	E. B. McCall, as above.
9	1857, April 4	5 44	
10	1858, February 4	5 47	
11	1858, December	5 50	
12	1873, December 1	6 52	Erving Taintor, local surveyor (azimuth determined from observations of Polaris).
13	1874, May 29, 30, June 2, 3, 4, 5, 6	6 55.7 W.	Dr. T. C. Hilgard, observer for United States Coast Survey, on hill about three-fourths of a mile north of railroad depot; MS. in Coast Survey archives.

BUFFALO, N. Y.

$\phi = 42° 52'.8$ $\lambda = 78° 53'.5$ W. of Gr.

(Light-house in the harbor.)

		° ′	
1	1797	0 00 W.	Amry Atwater, surveyor, east end of Lake Erie; MS. collection by Charles Whittlesey, communicated to the Coast Survey, March 26, 1860.
2	1798	0 30	Buffalo Reservation, Lake Shore. August Porter, in Twenty-second Report of Regents of University, New York. Albany, 1869.
3	1837	1 25	R. W. Haskins, $\phi = 42° 53'$, $\lambda = 78° 55'$; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
4	1839	1 15	At Fort Erie, $\phi = 42° 54'$, $\lambda = 78° 59'$; United States Lake Survey chart.
5	1845	1 25	Capt. Lefroy, Gen. Sir E. Sabine's Contributions, xiii, in Phil. Trans. Roy. Soc., 1872.
6	1859, June	2 56.5	Lieut. W. P. Smith, United States Lake Survey, $\phi = 42° 53'$, $\lambda = 78° 53'$, near south pier; Report of the United States Lake Survey, by Capt. Meade, Appendix B, Detroit, 1859.
7	1872, June 14	3 52.4	Capt. A. N. Lee, United States Lake Survey, $\phi = 42° 53'$, $\lambda = 78° 54'$; magnetic results, 1870–'73, Report of the Chief of Engineers for 1873, pp. 1195, 1197.
8	1873, June 4, 5	3 58.3 W.	

Collection of Magnetic Declinations, etc.—Continued.

TORONTO, PROVINCE OF ONTARIO, CANADA.

$\phi = 43° 39'.4$ $\lambda = 79° 23'.4$ W. of Gr.

(Magnetical and Meteorological Observatory.)*

		° ′	
1	1840, January	1 27 W.	Capt. C. J. B. Riddell, R. A. Phil. Trans. Roy. Soc., 1849.
2	1841	1 14.3	Vol. I, Toronto Observations, p. xi. Mean annual declinations. † 1° 19′.1 in the publication of 1875.
3	1842	1 18.9†	
4	1845	1 29.1	Vol. II, Toronto Observations, pp. iii-v. Mean annual declinations.
5	1846	1 30.8	
6	1847	1 33.2	
7	1848	1 35.4	
8	1849	1 36.9	
9	1850	1 38.6	
10	1851	1 40.9	
11	1853	1 46.1	Observations in July and August. Values corrected for annual and secular variations.
12	1854	1 48.0	Observations in February, March, April, and June. Values corrected for annual and secular variations.
13	1855	1 52.3	Observations from August to December, both inclusive. Values corrected for annual and secular variations.
14	1856	1 56.3	Mean annual declinations.
15	1857	2 00.5	
16	1858	2 04.5	
17	1859	2 07.4	
18	1860	2 10.6	
19	1861	2 14.3	
20	1862	2 15.7	
21	1863	2 19.1	
22	1864	2 21.9	
23	1865	2 24.8	
24	1866	2 27.6	
25	1867	2 29.8	
26	1868	2 33.2	
27	1869	2 37.1	Abstracts and results of magnetical and meteorological observations at the Magnetic Observatory, Toronto, Canada, from 1841 to 1871, inclusive, 1875. Mean annual declinations.
28	1870	2 41.9	
29	1871	2 47.9	
30	1872	2 53.0	Mean annual declinations, communicated February 28, 1881, by Charles Carpmael, director of the Toronto Magnetic Observatory, and superintendent of the Meteorological Service, Toronto, Ontario.
31	1873	2 58.3	
32	1874	3 04.1	
33	1875	3 11.7	
34	1876	3 18.5	
35	1877	3 24.9	
36	1878	3 31.4	
37	1879	3 37.3	
38	1880, October 18	3 41.1 W.	Communicated by C. Carpmael, director of Observatory, January 14, 1881.

* Results published by G. T. Kingston, M. A., director of the Magnetic Observatory, in the Canadian Journal, especially from two communications, "Monthly absolute values of the Magnetic Elements at Toronto, from 1856 to 1864, inclusive"; and "Monthly absolute values of the Magnetic Elements at Toronto, from 1865 to 1868, inclusive, with the annual means from 1841 to 1868."

Collection of Magnetic Declinations, etc.—Continued.

ERIE, PA.

$\phi = 42° 07'.8$ $\lambda = 80° 05'.4$ W. of Gr.

(Court-house.)

		° ′		
1	1786, October	0 32	W.	New York and Pennsylvania boundary line; monument on French Creek, in $\phi = 42° 00'$, $\lambda = 79° 58'$, about 10 miles S.SE. of Erie. Geological Survey of New York. See also a map in the State Department of New York, on which the observed variations are given, "protracted by Abm. Hardenberg, one of the Commissioners for the State of New York, October 29, 1787."
2	1795	0 43	E.	Andrew Ellicott, in $\phi = 42° 08'.2$, $\lambda = 80° 05'.2$ Stone monument corner Parade and Front streets; Am. Alm. of 1861, p. 54.
3	1841, August 9	0 30	W.	Dr. A. D. Bache, magnetic survey of Pennsylvania; Coast Survey Report of 1862, p. 213.
4	1855	1 33		Annual Report of Secretary of Internal Affairs of Pennsylvania for 1877. Harrisburg, 1878.
5	1859, April	1 34		Samuel Low, at meridian line established by him in cemetery. Mean of 9 years' observations, 1855 to 1863, inclusive. From Annual Report of Secretary of Internal Affairs, Commonwealth of Pennsylvania. Harrisburg, 1876, p. 20 A. In $\phi = 42° 09'$, $\lambda = 80° 05'$.
	1859, June	1 44.4		Lieut. W. P. Smith, Survey North and Northwest Lakes, Capt. G. G. Meade in charge; at Presque Isle Harbor. $\phi = 42° 09'.8$, $\lambda = 80° 05'.3$. Mean of two values, 1° 39′.2
6	1862, August 6, 7	1 33		C. A. Schott, assistant Coast Survey. Same place as in Dr. Bache's survey, near Mr. Reed's house, Seventh street, in $\phi = 42° 07'.5$, $\lambda = 80° 05'.3$; Coast Survey Report of 1862, p. 212.
7	1867, April	2 13		Samuel Wilson, at meridian line in cemetery; mean of 7 years of observations, 1864 to 1870, inclusive. Annual Report of Secretary of Internal Affairs of Pennsylvania, 1876.
8	1873, June 12, 13	2 00.7		Capt. A. N. Lee, United States Lake Survey, in $\phi = 42° 08'.2$, $\lambda = 80° 05'.3$ Magnetic results, 1870 to 1873; Report of Chief of Engineers for 1873, pp. 1195, 1197.
	1873, October	2 36		Samuel Wilson, at meridian line in cemetery; mean of 6 years of observations, 1871 to 1876, inclusive. Annual Report of Secretary of Internal Affairs of Pennsylvania, 1876.
9	1876	2 50		Annual Report of Secretary of Internal Affairs of Pennsylvania, 1876.
10	1877, November	3 00	W.	Annual Report of Secretary of Internal Affairs of Pennsylvania for 1877. Harrisburg, 1878.

MARIETTA, OHIO.

$\phi = 39° 25'$ $\lambda = 81° 28'$ W. of Gr.

		° ′		
1	1810	2 36	E.	J. Mansfield; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1823–24	3 30		Boye; at Parkersburg, $\phi = 39° 16'$, $\lambda = 81° 34'$. Boye's State map of Virginia. [Reduction to Marietta about $+ 5'$.]
3	1838	1 29		Prof. E. Loomis; reference as above. $\phi = 39° 25'$, $\lambda = 81° 26'$.
	1838	1 36		B. E. Stone; near Marietta, in $\phi = 39° 31'$, $\lambda = 81° 26'$. Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840.
4	1845, April	2 25		Henk's Field-book.
5	1850	1 25		A. D. Bache's table in Gillespie's Treatise on Land Surveying.
6	1864, January 26	1 17.6	E.	A. T. Mosman, assistant Coast and Geodetic Survey, at Parkersburg, in $\phi = 39° 16'.0$, $\lambda = 81° 34'.2$ [Reduction to Marietta as above.]
7	1881, May 30, 31	0 07.2	W.	J. B. Baylor, United States Coast and Geodetic Survey. At Parkersburg station of 1864.

Collection of Magnetic Declinations, etc.—Continued.

CLEVELAND, OHIO.

$\phi = 41° 30'.3$ $\lambda = 81° 42'.0$ W. of Gr.

		°	′		
1	1796, September	2	00	E.	Aug. Porter and Seth Pease, in $\phi = 41° 30'$, $\lambda = 81° 40'$; MS. compiled by Charles Whittlesey, March, 1860, Coast Survey archives.
2	1830	1	20		Ahaz Merchant: Prof. E. Loomis' collection, Sill. Jour., vol. xxxix, 1840.
3	1831, August	1	15		Edwin Foote; MS. compiled by Charles Whittlesey, 1860.
4	1834 (winter)	0	50		Ahaz Merchant; Prof. E. Loomis' collection, as above.
5	1838 (winter)	0	35		Ahaz Merchant; reference as above.
6	1840	0	19		Prof. E. Loomis; Phil. Trans. Roy. Soc., 1872, General Sabine's Contributions, xiii. Misprinted = 1° 19′ E. See Dr. C. Davies on "Surveying."
7	1841, May 1	0	05.2		J. N. Pillsbury; MS. compiled by Charles Whittlesey, 1860.
8	1845	0	39	E.	From a chart of survey of North and Northwest Lakes, Topographical Engineers; beacon-light, in $\phi = 41° 31'$, $\lambda = 81° 41'.5$
9	1859, July 5	0	46	W.	Lieut. W. P. Smith, Topographical Engineers, in $\phi = 41° 30'$, $\lambda = 81° 40'$; MS. by Charles Whittlesey, also MS. by W. F. Raynolds, major of Engineers, Survey of North and Northwest Lakes.
	1865	1	12	E.(?)	MS. (December, 1865) by W. F. Raynolds, major of Engineers, as above. [Value not used.—SCH.]
10	1871, November 9-11	0	32.6	W.	E. Goodfellow, assistant Coast Survey; Coast Survey archives; at Marine Hospital, in $\phi = 41° 30'.4$, $\lambda = 81° 41'.5$
11	1872, June 17, 18	0	44.9		Capt. A. N. Lee, United States Lake Survey; Report of Chief of Engineers for 1873.
12	1873, June 16, 17	0	50.9		Capt. A. N. Lee, United States Lake Survey; reference as above.
13	1880, July 9, 10, 12	1	38.5	W.	J. B. Baylor, United States Coast and Geodetic Survey. Station of 1871, grounds of the City Hospital.

DETROIT, MICH.

$\phi = 42° 20'.0$ $\lambda = 83° 03'.0$ W. of Gr.

		°	′		
1	1810	2	48	E.	J. Mansfield; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. Position assigned, $\phi = 42° 30'$, $\lambda = 82° 58'$.
2	1822	3	13		L. Lyons } Prof. E. Loomis' collection, in Sill. Jour., vol. xxxix, 1840. Position assigned, $\phi = 42° 24'$, $\lambda = 82° 58'$.
3	1828	2	50		L. Lyons
4	1835	2	10		Geological Report
5	1840	2	00		Geological Report
	1840	1	56		Prof. E. Loomis; Gen. Sir E. Sabine, Phil. Trans. Roy. Soc., 1872, Contributions, No. xiii.
6	1859, April	0	42		United States Lake Survey, MS. communicated by Col. W. F. Raynolds, United States Engineers. Position, $\phi = 42° 20'$, $\lambda = 83° 03'$.
7	1865	0	40		
8	1872, May 8–29	0	25.2		United States Lake Survey, Gen. C. B. Comstock, U. S. A., superintendent; Report of the Chief of Engineers for 1873, pp. 1195–1197; Capt. A. N. Lee, U. S. A., observer. Positions assigned, $\phi = 42° 20'.0$, $\lambda = 83° 02'.5$
9	1873, May 5–17	0	17.3		
10	1876, June 3, 6	0	04.7	E.	U. S. Lake Survey; Report of Chief of Engineers for 1877, vol. 2. Lieut. T N. Bailey, observer. Position, $\phi = 42° 20'.0$, $\lambda = 83° 03'.1$

SAULT DE STE. MARIE, MICH.

$\phi = 46° 29'.9$ $\lambda = 84° 20'.1$ W. of Gr..

(Garden of Fort Brady.)

		°	′		
1	1790 (?)	0	00	E.	Alexander Mackenzie; Voyages through the continent of North America, London, 1801. Falls of St. Mary, in $\phi = 46° 31'$, $\lambda = 84° 00'$.
2	1843	1	08		Capt. Lefroy. Sir E. Sabine, Phil. Trans. Roy. Soc., Cont. xiii, 1872.
3	1845	0	46		Capt. Lefroy. Sir E. Sabine, Phil. Trans. Roy. Soc., Cont. xiii, 1872; assigned position in $\phi = 46° 31'$, $\lambda = 84° 32'$.
4	1846, November	0	40		Lieut. G. C. Westcott, U. S. A. Information by Mr. J. B. Baylor.
5	1856, September 29	0	32.1	E.	Karl Friesach, Kais. Acad. der Wiss., vol. 29; Vienna, 1858; assigned position $\phi = 46° 30'$, $\lambda = 84° 34'$.
6	1873, July 22, 23	0	04.9	W.	Capt. A. N. Lee, U. S. Engineers. Survey of the N. and N. W. Lakes, Gen. C. B. Comstock in charge; MS. of 1873; also report of Chief of Engineers, 1874, app. CC; $\phi = 46° 30'.1$, $\lambda = 84° 20'.0$
7	1879, November 12	1	01.0		City Surveyor at Fort Brady. Information by Mr. J. B. Baylor.
8	1880, July 11, 13, 14, 17, 19	0	53.7		Lieut. S. W. Very, U. S. N., Act. Assist. Coast and Geodetic Survey. At vegetable garden of Fort Brady. $\phi = 46° 29'.9$, $\lambda = 84° 20'.1$
	1880, August 6, 7	1	04.5	W.	J. B. Baylor, U. S. Coast and Geodetic Survey. Military post garden about 30 yards N. W. of Lieutenant Very's station of 1880. Position as above.

Collection of Magnetic Declinations, etc.—Continued.

CINCINNATI, OHIO.

$\phi = 39° 06'.4$ $\lambda = 84° 29'.8$ — Old Astronomical Observatory on Mt. Adams.

$\phi = 39° 08'.6$ $\lambda = 84° 25'.3$ — New Astronomical Observatory on Mt. Lookout.

		° ′	
1	1806	4 58 E.	Public Surveys; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxix, 1840. In $\phi = 39° 06'$, $\lambda = 84° 27'$.
2	1810	5 00	J. Mansfield; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. In $\phi = 39° 07'$, $\lambda = 84° 27'$.
3	1840, January 11	4 46	Dr. J. Locke; Survey of Mineral Lands, Exec. Doc., 1839–'40, vol. vi. In $\phi = 39° 06'$, $\lambda = 84° 27'$.
4	1845, April	4 04	Dr. J. Locke; U. S. Coast Survey Report for 1855, p. 304. In $\phi = 39° 06'$, $\lambda = 84° 22'$.
5	1880, November 27, 29, 30	2 14.4 E.	J. B. Baylor, U. S. Coast and Geodetic Survey. Grounds of new astronomical observatory on Mt. Lookout.

ST. LOUIS, MO.

$\phi = 38° 38'.0$ $\lambda = 90° 12'.2$ W. of Gr.

(Washington University.)

		° ′	
1	1819, June 17	10 47.6 E.*	Maj. S. H. Long; at St. Louis, in $\phi = 38° 36'$, $\lambda = 90° 06'$. [Longitude about 5′ in error.—SCH.] Account of an expedition from Pittsburg to the Rocky Mountains in 1819 and 1820, by Maj. S. H. Long, Philadelphia, 1823.
2 {	1835	8 49	Colonel Nicolls; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
	1838	7 45	De Ward, surveyor. In City Commons. Letter of Thomas Featherson, of June 18, 1877. Communicated by Assistant W. Eimbeck, Coast Survey.
3 {	1855	8 00	Colton's General Atlas, New York, 1873.
	1856, October 31	6 23.1	Karl Friesach, Berichte der Kais. Akad. der Wiss., Vienna, vol. xxix, 1858.
4	1872, June, July, and August	6 37.5	Dr. T. C. Hilgard, observer; Bache-Fund Magnetic Survey; MS. communication. Two stations, south and west of court-house; first, on Compton Hill, $-6° 35'.2$ in $\phi = 38° 37'.1$, $\lambda = 90° 14'.0$; second, near City Hospital, $-6° 39'.9$ in $\phi = 38° 36'.5$, $\lambda = 90° 12'.7$ [Mean $-6° 37'.5$—SCH.]
5	1877, June	6 30.5	Thomas Featherson, deputy county surveyor, St. Louis Co. From comparisons of 17 old lines run in the City Commons in 1838 by De Ward, surveyor. Communicated by W. Eimbeck, assistant Coast Survey. Annual change since 1838, $+ 1'.91$
6	1878, August 14, 15	6 33.7	Prof. F. E. Nipher, Washington University; Trans. St. Louis Acad. Sciences; observations in vacant square, SE. corner Garrison ave. and Dickson st.; used Coast Survey instruments.
7	1879, September 9	6 13.3 E.	Prof. F. E. Nipher, corner Garrison ave. and Glasgow Place. Communicated Oct. 14, 1879.

* This value is probably somewhat too great.—SCH.

NEW YORK AND VICINITY, N. Y.

$\phi = 40° 42'.7$ $\lambda = 74° 00'.4$ W. of Gr.

(New York City Hall.)

		° ′	
	1609, September 2	8 W.	Hudson, on his third voyage, near the Jersey shore, a little below the mouth of Hudson River. The day before he found not above 2° W. [See reference below. Observation not used.] Hudson, on his third voyage, a few miles up the Hudson River, found, 1609, Sept. 13, 13° W. This observation may have been made on shore. Prof. E. Loomis' collection, in Sill. Jour., vol. xxxix, 1840; extract furnished by Prof. J. Sparks from 3d vol. of Purchas' Pilgrims. [Observation not used.]
1	1684	8 45	Philip Welles, Surveyor-General; Report of the N. Y. Commissioners on the Connecticut Boundary, made to the New York Legislature in April, 1857 [Sen. Doc. 165, p. 155]. Received from J. H. Trumbull, April, 1876.
2	1686	9 0	George Keith, at Sandy Hook. Line run between E. and W. New Jersey. Records of proprietors of New Jersey. Communicated by Prof. G. H. Cook, State Geologist of N. J., Oct. 11, 1879.
3	1691	8 45	On Staten Island; Geological Survey of New York, 1858, E. Duxbury's patent. [See also E. Halley's isogonic chart for the epoch 1700, reproduced by photolithography in the "Greenwich Observations of 1869." It gives about 8° W. for New York.]
	1714	8 45	John Beatty, deputy surveyor, on map of Livingston's Manor (N. Y.). Engraved in O'Callaghan's Doc. Hist. N. Y., iii, 414. Received from J. H. Trumbull. [Not used.]

Collection of Magnetic Declinations, etc.—Continued.

NEW YORK AND VICINITY, N. Y.—Continued.

		° ′	
4	1723	7 20 W.	G. Burnet; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
	1724	7 20	Cadwallader Colden, one of the commissioners of the New York and Connecticut boundary of 1724. (See Report of Commissioners of 1857, as above.) Received from J. H. Trumbull.
5	1750	6 22	Mr. Alexander; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
6	1755	5 00	Mr. Evans; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
	1775	7	J. F. W. Des Barres' Atlantic Neptune, London, 1781, at Sandy Hook, New York Bay. [Not used.]
7	1789	4 20	Prof. Loomis' collection of 1838; also Encyc. Metrop., 1848.
8	1824	4 40	Blunt's map; Prof. E. Loomis' collection of 1838.
9	1834	4 50	Captain Owen; Prof. E. Loomis' collection of 1838.
10	1837	5 40	Prof. J. Renwick, Columbia College; Prof. E. Loomis' collection of 1838.
11	1840, June 16 to July 11	5 01	Lieut. S. C. Rowan, U. S. N., observer for United States Coast Survey, at Howard, Staten Island, in $\phi = 40° 37'.6$, $\lambda = 74° 05'.4$; MS. in Coast Survey archives.
	1840, July 18 to October 16	5 53	Lieut. S. C. Rowan, U. S. N., observer for United States Coast Survey, at Bergen Neck, in $\phi = 40° 45'.8$, $\lambda = 74° 02'.6$; MS. in Coast Survey archives.
12	1841	6 06	Douglass' map of New Jersey; Coast Survey archives.
	1842, September	5 32.5	Coast Survey determination (observer not stated) at Sandy Hook, in $\phi = 40° 27'.7$, $\lambda = 74° 00'.2$; MS. in Coast Survey archives.
	1844, January	5 51.1	Lieuts. G. M. Bache and J. Hall, U. S. N., observers for United States Coast Survey, at Sandy Hook (same place as in 1842); MS. in Coast Survey archives.
	1844, August 20–22	5 51.0	Prof. J. Renwick, observer for United States Coast Survey at Sandy Hook, in $\phi = 40° 27'.7$, $\lambda = 74° 00'.2$; Coast Survey Report for 1854, p. 144*.
13	1844, August 24	6 13.1	Prof. J. Renwick, observer for United States Coast Survey, at Columbia College (old position), in $\phi = 40° 42'.7$, $\lambda = 74° 00'.5$; reference as above.
14	1845, September 4	6 25.3	Prof. J. Renwick, observer for United States Coast Survey, at Columbia College; reference as above.
15	1846, April 30	5 09.7	Dr. J. Locke, observer for United States Coast Survey, at Bloomingdale Asylum, in $\phi = 40° 50'.3$, $\lambda = 73° 56'.7$; Coast Survey Report for 1854, p. 144*.
	1846, May 4	5 54.7	Dr. J. Locke, observer for United States Coast Survey, at Mount Prospect (formerly Flatbush), Brooklyn, in $\phi = 40° 40'.3$, $\lambda = 73° 58'.0$; reference as above. Other observations at this place are given in the Regents' Report of the University of the State of New York, viz: Oct., 1834 4° 25′ W.; Oct., 1835 4 45; Oct., 1837 4 45; Dec. 18, 1838 4 45; Jan. 4, 1840 4 55; Dec. 22, 1840 5° 00′ W.; Dec. 30, 1841 5 12; Dec. 30, 1842 5 10; Dec. 20, 1847 5 30; Oct. 26, 1848 5 15; Assigned position $\phi = 40° 37'$, $\lambda = 73° 58'$.
	1846, May 14	5 35.1	Dr. J. Locke, observer for United States Coast Survey, at Newark, in $\phi = 40° 44'.8$, $\lambda = 74° 07'.3$; Coast Survey Report for 1854, p. 144*.
16	1847, October 16, 20	5 41.0	R. H. Fauntleroy, assistant Coast Survey, at Legget, in $\phi = 40° 48'.9$, $\lambda = 73° 53'.4$; reference as above.
17	1855, August 7	6 39 6	C. A. Schott, assistant Coast Survey, at Governor's Island, in $\phi = 40° 41'.5$, $\lambda = 74° 01'.0$; Coast Survey Report for 1855, p. 337.
	1855, August 8	7 02.1	C. A. Schott, at Bedloe's Island, in $\phi = 40° 41'.4$, $\lambda = 74° 02'.7$; reference as above.
	1855, August 11	6 28.0	C. A. Schott, at Receiving Reservoir (now in Central Park), in $\phi = 40° 46'.7$, $\lambda = 73° 58'.2$; reference as above.
	1855, August 14	6. 11.2	C. A. Schott, at Sandy Hook; position same as in 1844; reference as above. To reduce to New York add 22′.4 or 0°.37 [Not used.]
18	1860, September 21, 22	6 44.0	C. A. Schott, at site at Mount Prospect, now Brooklyn (new) water-works, in $\phi = 40° 40'.3$, $\lambda = 73° 58'.0$; Coast Survey Report for 1860, p. 352.
	1872, October 31, November 1 and 2.	8 45.8	A. H. Scott, United States Coast Survey, at Central Park, west of Mall, in $\phi = 40° 46'.2$, $\lambda = 73° 58'.2$; MS. in Coast Survey archives. [Not used.]
19	1873, November 5, 6, 7, 9	7 09.0	Dr. T. C. Hilgard, observer for United States Coast Survey, at Sandy Hook; station as in 1844; MS. in Coast Survey archives. To reduce to New York add 0°.37
20	1874, August	7 23	Report of Chief of Engineers U. S. A. for 1875; chart of Way Reef, Hell Gate.
21	1879, July 17, 18	7 32.0 W.	J. B. Baylor, United States Coast and Geodetic Survey. Station of 1873, at Sandy Hook, N. J. To reduce to New York add 0°.37

Collection of Magnetic Declinations, etc.—Continued.

HATBOROUGH, MORELAND TOWNSHIP, MONTGOMERY COUNTY, PA.

$\phi = 40° 12'$ $\lambda = 75° 07'$ W. of Gr.

		° ′		
1	1680	8 28	W.	Table communicated to the Superintendent of the Coast Survey in a letter, by Mr. E. W. Beans, dated Hatborough, March 1, 1852 (see Coast Survey Report for 1855, p. 312). [It is not to be presumed that this table presents direct observations, as the regularity of decennial values sufficiently attests; but it is not doubted that it rests upon *reliable* observations of numerous bearings of old (and new) lines which were submitted to some process of interpolation, probably graphical.—SCH.]
2	1690	8 15		
3	1700	7 55		
4	1710	7 28		
5	1720	7 00		
6	1730	6 25		
7	1740	5 35		
8	1750	4 55		
9	1760	4 00		
10	1770	2 55		
11	1780	2 05		
12	1790	1 50		
13	1800	1 55		
14	1810	2 00		
15	1820	2 27		
16	1830	3 00		
17	1840	3 50		
18	1850	4 25	W.	

PHILADELPHIA, PA.

$\phi = 39° 56.9$ $\lambda = 75° 09'.0$ W. of Gr.

(State-house.)

		° ′		
1	1701	8 30	W.	By Mr. Scull, as stated by G. Gillet, Sill. Jour., vol. xxiii, 1833. [See also Coast Survey Report for 1855, pp. 313, 314.]
2	1710	8 30		Th. Whitney; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
3	1750	5 45		Kalm's Travels; reference as above.
4	1793	1 30		Th. Whitney; reference as above.
	1793	1 30		By Mr. Brooks; Sill. Jour., vol. xxiii, 1833.
5	1802	1 30		By Mr. Howell; reference as above.
6	1804	2 00		By several men of science; reference as above.
	1804	2 10		Th. Whitney; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
7	1813	2 25		D. McClure; reference as above.
	1813	2 27		By Mr. Whitney; Sill. Jour., vol. xxxiv, 1833.
8	1837	3 52		W. R. Johnson; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
9	1840, June	3 37		Dr. A. D. Bache, at Girard College, $\phi = 39° 58'.3$, $\lambda = 75° 10'.3$; annual change from *differential observations* between 1840, June, and 1845, December, $= 4'.4$ (Coast Survey Reports for 1859, p. 285, and 1860, p. 311); subtracting 5′.3 from his observation, 3° 53′.7 July 20 and November 1, we find 3° 48′ for June, 1840; again subtracting 26′ from Dr. Locke's observation, 3° 51′.1, in May, 1846, we find 3° 25′; mean adopted, 3° 37′.†
10	1841, July 20 and November 1	3 53.7		Dr. A. D. Bache, at Girard College; magnetic survey of Pennsylvania; Coast Survey Report for 1862, p. 213.
11	1846, May 23	3 51.1		Dr. J. Locke, Girard College magnetical observatory; Coast Survey Report for 1854, p. 144.*
12	1855, September 5	4 31.7		C. A. Schott, assistant Coast Survey, east of main building, Girard College; Coast Survey Report for 1855, p. 337.
13	1862, August 15, 16	5 00.0		C. A. Schott, assistant Coast Survey, at site of old magnetical observatory, Girard College; Coast Survey Report for 1862, p. 212.
14	1872, October 19, 20, 21	5 27.8		A. H. Scott, United States Coast Survey, at site of old magnetical observatory, Girard College; MS. in Coast Survey archives.
15	1877, October 2, 3, 5, 6	6 02.2	W.	J. B. Baylor, United States Coast Survey, Girard College, SW. of main building.

† Which is preferred to the values given in Coast Survey Report for 1864, p. 204.—SCH.

Collection of Magnetic Declinations, etc.—Continued.

HARRISBURG, PA.

$\phi = 40° 15'.9$ $\lambda = 76° 52'.9$ W. of Gr.

(State Capitol.)

		° ′	
1	1795, August 19	0 26 E.	From a map of the borough of Harrisburg on file in office of register and recorder of this county, made by Thomas Foster. Communicated by W. W. Wright, March 10, 1875.
2	1840, July 25	3 12.5 W.	Dr. A. D. Bache; in the grounds east of the capitol; Coast Survey Report of 1862, p. 212.
3	1843	2 35	From a map of the borough of Harrisburg, on file in the city register's office, made by John Roberts. Communicated by W. W. Wright, March 10, 1875.
4	1854 (autumn)	3 06	John Roberts and Samuel Hoffer, surveyors, established a true meridian east of the State House. Communicated by W. W. Wright, February, 1875. [See also Annual Report of Secretary of Internal Affairs of Pennsylvania for 1876.]
5	1857, April 29	3 18.3	James Ferguson, James Aspach, and Daniel Hoffman, surveyors. Results recorded at county commissioner's office. Communicated by W. W. Wright, February, 1875.
	1857, June 3	3 20	Samuel Hoffer; reference as above.
6	1860-'61	3 30	From surveys made by Hather Page;* map in the city register's office at Harrisburg. Communicated by W. W. Wright, March 10, 1875.
7	1862, July 28, 29	3 44.5	C. A. Schott, assistant Coast Survey; grounds of the State House, near eastern entrance; Coast Survey Report of 1862, p. 212.
8	1874, October and November	4 51	H. Alricks, jr., J. Simpson Africa; Annual Report of Secretary of Internal Affairs of Pennsylvania, 1876; W. McCandless, secretary.
9	1876, December 2	5 10	Annual Report of Secretary for 1876, as above.
10	1877, September 25, 26	4 53.5 W.	E. Smith and J. B. Baylor, United States Coast Survey; grounds east of capitol, near astronomical station and near station of 1862, $\phi = 40° 15'.8$, $\lambda = 76 52'.9$

* Name not clearly legible.

BALTIMORE, MD.

$\phi = 39° 17'.8$ $\lambda = 76° 37'.0$ W. of Gr.

(Washington Monument.)

		°	
1	1679.0	5.25 W.	Values depending on resurvey of old lines from facts given by T. Kelbaugh.* $D_{1679.0} = D_{1814.5} + 4°.50$ Adopted value for second epoch $+ 0°.75$
2	1683.5	6.25	$D_{1683.5} = D_{1814.5} + 5°.50$ Adopted value for second epoch $+ 0.75$
3	1703.5	5.12	$D_{1703.5} = D_{1811.8} + 4°.43$ Adopted value for second epoch $+ 0.69$
4	1720.5	4.21	$D_{1720.5} = D_{1816.0} + 3°.42$ Adopted value for second epoch $+ 0.79$
5	1729.2	4.02	$D_{1729.2} = D_{1807.1} + 3°.39$ Adopted value for second epoch $+ 0.63$
6	1754.5	2.28	$D_{1754.5} = D_{1855.5} - 0°.37$ Adopted value for second epoch $+ 2.65$
7	1756.9	2.88	$D_{1756.9} = D_{1815.0} + 2°.12$ Adopted value for second epoch $+ 0.76$
8	1771.0	1.11	$D_{1771.0} = D_{1846.5} - 1°.00$ Adopted value for second epoch $+ 2.11$
9	1776.1	1.75	$D_{1776.1} = D_{1811.4} + 1°.07$ Adopted value for second epoch $+ 0.68$
10	1780.5	0.77	$D_{1780.5} = D_{1861.5} - 2°.25$ Adopted value for second epoch $+ 3.02$
11	1787.5	0.37	$D_{1787.5} = D_{1851.0} - 2°.00$ Adopted value for second epoch $+ 2.37$
12	1808.5	0° 12′.5	D. Byrnes, from numerous observations in Baltimore in different localities; Sill. Jour., vol. xviii, 1830.
13	1840, August 27	2 16.5	Dr. A. B. Bache; Coast Survey Report for 1862, p 213.
14	1847, April 29	2 18.6	Capt. T. J. Lee, United States Engineers, assistant Coast Survey; at Fort McHenry, in $\phi = 39° 15'.8$, $\lambda = 76° 34'.8$; Coast Survey Report for 1854, p. 144.
15	1856, September 13	2 29.3	C. A. Schott, assistant Coast Survey; just outside Fort McHenry, in $\phi = 39° 15'.9$, $\lambda = 76° 34'.9$; Coast Survey Report for 1858, p. 191.
16	1875.5	3°.74	See note *. $D_{1875.5} = D_{1857.0} + 1°.00$. Adopted value for second epoch $+ 2°.74$
17	1877, October 10, 11, 12	4° 10′.8 W.	J. B. Baylor, United States Coast Survey; at Fort McHenry, near station of 1856.

* Mr. Thomas Kelbaugh, surveyor at Mt. Carmel, Baltimore County, Maryland, communicated to the Coast Survey Office (letters dated August 17 and 24, 1877, and April 28, 1879) 52 cases of observed or allowed for changes of magnetic declinations between given dates, mostly from redeterminations of magnetic bearings of old lines, made with the common surveyor's compass, by different individuals and with different instruments, and generally within a radius of 15 statute miles of Baltimore City, on the N., NE., and NW. of it. These surveys were made by order of the Baltimore County circuit court, arising from disputed land cases. Other values were copied from the record-book of the county surveyor and his assistants, between 1805 and 1825.

The 52 differential values, after scrutiny, were properly combined; the 12 results, Nos. 1 to 11, inclusive, thus obtained are given in the above table. The adopted values for the epochs of the resurvey are likewise given, and are those resulting from a formula established by me in August. 1877. At that time but 25 differential values had been communicated by Mr. Kelbaugh.—[SCH.]

Collection of Magnetic Declinations, etc.—Continued.

WASHINGTON, D. C.

$\phi = 38° 53'.3$ $\lambda = 77° 00'.6$ W. of Gr.

(United States Capitol.)

		° ′		
	1792	0 51	E.	Maj. A. Ellicott, surveyor-general; inscription on fourth milestone northwesterly from east corner of District; reported by G. Mathiot. [Supposed affected by local deviation; not used.]
1	1792	0 19		A. Ellicott; inscription on first milestone northwesterly from east corner of District; reported by J. Wiessner.
	1792	0 10	E.	A. Ellicott; inscription on east corner-stone, District; reported by J. Wiessner.
2	1809, December	0 52	W.	Nicholas King, surveyor of the city of Washington; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
3	1841.0	1 20.2		J. M. Gilliss, U. S. N.; Capitol Hill, north of Capitol; Sen. Doc., 2d sess. 28th Cong., 1844-45.
4	1842.0	1 23.9		J. M. Gilliss, U. S. N.; reference as above.
5	1855, July	2 24		C. A. Schott, assistant Coast Survey; Coast Survey Report for 1855, p. 334, on Capitol Hill, near Gilliss station.
6	1856, August 14, 20	2 21.4		C. A. Schott, at (old) Coast Survey Office, Capitol Hill; also 2° 01′ W., August 15, in park east of the Capitol; Coast Survey Report for 1856, p. 227.
7	1857, March 9	2 24.8		W. Read; near Capitol, south side; Coast Survey Report for 1858, p. 196. Communicated by observer.
8	1860, August 16 to September 26.	2 26.7		C. A. Schott, at (old) Coast Survey Office; $\phi = 38° 53'.1$, $\lambda = 77° 00'.6$; Coast Survey Report for 1860, p. 352.
9	1862, August, 18, 19	2 39.4		C. A. Schott, at (old) Coast Survey Office; Coast Survey Report for 1862, p. 212.
10	1863, June 18 to July 28	2 41.8		C. A. Schott, at (old) Coast Survey Office; Coast Survey Report for 1863, p. 204.
11	1866, November 1	2 44.2		Prof. W. Harkness, U. S. N.; United States Naval Observatory grounds, in $\phi = 38° 53'.7$, $\lambda = 77° 03'.1$; Smithsonian Contributions to Knowledge, No. 239, p. 61, Washington, 1873.
12	1867, January to December	2 48.1		C. A. Schott, at magnetic observatory, corner Second street east and C street south Captiol Hill, in $\phi = 38° 53'.1$, $\lambda = 77° 00'.2$; Monthly Determinations, Coast Survey Report for 1899, pp. 199-207.
13	1868, January to December	2 51.2		
14	1869, January to June, inclusive.	2 53.0		
15	1870, June 13, 14, 15	2 53.6		C. A. Schott, at magnetic observatory, corner Second and C streets southeast; Coast Survey Report for 1870, Appendix No. 14.
16	1871, June 14, 15, 16	2 56.9		
17	1872, June 14, 15, 17	3 00.0		
18	1873, June 14, 16, 17	3 00.1		Observer and locality as before; MS. Coast Survey archives.
19	1874, June 13, 15, 16	3 07.4		
	1874, July 20, 21, 22	3 05.2		
20	1875, June 12, 14, 15	3 15.5		Observer and locality as before; MS. Coast Survey archives.
21	1876, May 1, 2	3 18.8		
22	1877, June 14, 15, 16	3 42.1		C. A. Schott, at new magnetic observatory, near corner First and B streets southeast; $\phi = 38° 53'.2$, $\lambda = 77° 00'.4$; MS. in Coast Survey archives.
	1877, August 17	3 36.8		A. Braid, United States Coast Survey: same place.
23	1878, June 14, 15, 17	3 47.5		C. A. Schott; locality as above.
	1878, September 8	3 43.0		Dr. T. E. Thorpe; locality as above.
24	1879, June 9, 10, 11	3 50.4		W. Eimbeck and C. A. Schott, assistants Coast and Geodetic Survey; locality as in 1877 and 1878.
25	1880, February 23, 24, 25	3 52.4		M. Baker, United States Coast and Geodetic Survey; locality as above.
	1880, April 3	3 57.2		J. B. Baylor, United States Coast and Geodetic Survey; locality as above.
	1880, June 12, 14, 17	3 57.1		
26	1882, June 15, 16, 17	3 55.4	W.	W. Eimbeck, assistant Coast and Geodetic Survey; locality as in 1877.

Collection of Magnetic Declinations, etc.—Continued.

CAPE HENRY, VA.

$\phi = 36° 55'.6$ $\lambda = 76° 00'.4$ W. of Gr.

(Light-house, 1882.)

		° ′		
	1728, March 6	3 00	W.	W. Byrd, at head of Currituck Sound, in $\phi = 36° 30'$; Westover MS. (Two printed copies in Library of Congress.) Reduction to Cape, +20′.
1	1732	4 42		W. Hoxton, seven miles from Cape Henry, in $\phi = 36° 50'$; Hansteen's Magnetismus der Erde, 1819.
	1732	4 40		Douglass' History, in $\phi = 37° 07'$, $\lambda = 75° 30'$; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
	1775	5 00		J. F. W. Des Barres' Atlantic Neptune, London, 1781. [Not used.]
2	1809	0 00		President Madison, at Norfolk, in $\phi = 36° 51'$, $\lambda = 76° 19'$; Prof. E. Loomis' collection Sill. Jour., vol. xxxiv, 1838. Reduction to Cape −8′; by observations of 1856.
	1823–24	1 32		State map of Virginia, of 1859, by H. Boye. [Not used.]
3	1832, June 9, 11	0 45		Prof. J. N. Nicollet; Coast Survey Report for 1864, p. 210.
4	1856, September 11, 12	1 28		C. A. Schott, assistant Coast Survey, in $\phi = 36° 55'.6$, $\lambda = 76° 00'.4$; Coast Survey Report for 1856, p. 227.
5	1874, November 26, 27, 28	2 39.5		Dr. T. C. Hilgard, observer for United States Coast Survey; MS. in Coast Survey archives.
6	1879, May and June	2 32	W.	Lieut. Samuel W. Very, U. S. N. From 50 observations at the Rip Raps. [Reduction to Cape Henry, according to my observations of 1856, +13′—SCH.]

CHARLESTON, S. C.

$\phi = 32° 46'.6$ $\lambda = 79° 55'.8$ W. of Gr.

(St. Michael's Church.)

		° ′		
	1700	0 30	E.	E. Halley's isogonic chart for 1700; reproduced by photolithography in the Greenwich observations for 1869. [Not used.]
	1742	5 23		English Pilot, published on Tower Hill in 1794; extracted from a paper by Andrew Hughes. [Not used.]
1	1775	3 48		Des Barres' Atlantic Neptune, London, 1781.
	1777	3 48		From a chart; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838, probably the same as that given in the Neptune. [Not used.]
2	1784, February	5 15		Joseph Purchell, surveyor; see pamphlet by Charles Parker, Charleston, 1849.
3	1785, October	5 45		[Observations said to come from a reliable source.]
4	1824–25	3 45		Lieut. Sherburne, U. S. N.; Blunt's chart of 1824–25.
5	1837	2 54		Capt. Missroom; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. Position $\phi = 32° 47'$, $\lambda = 79° 57'$.
6	1840	2 44		Dr. C. Davies, in his treatise on surveying.
7	1841, May	2 24		Barnet; Phil. Trans. Roy. Soc., vol. for 1849.
8	1847, October	2 15		Charles Parker; see his pamphlet (Charleston, 1849).
9	1849, April 1 and 22	2 16.5		C. O. Boutelle, assistant Coast Survey, at Breach Inlet, in $\phi = 32° 46'.3$, $\lambda = 79° 48'.9$ Sullivan's Island; Coast Survey Report for 1854, p. *145.
10	1874, May 27, 28, 29	0 58.1		C. O. Boutelle, assistant Coast Survey, at Fort Marshall, same position as for Breach Inlet; MS. in Coast Survey archives.
11	1880, January 21, 22	0 25.6	E.	J. B. Baylor, United States Coast and Geodetic Survey, at Breach Inlet, Sullivan's Island; $\phi = 32° 46'.4$, $\lambda = 79° 48'.8$

SAVANNAH, GA.

$\phi = 32° 04'.9$ $\lambda = 81° 05'.5$ W. of Gr.

(Savannah Exchange.)

		° ′		
1	1817	4	E.	Becquerel's Traité du Magnétisme, Paris, 1846; Cartes du Dépôt, in $\phi = 32° 04'$, $\lambda = 80° 40'$.
2	1838	5 05		Geological Survey, in $\phi = 32° 05'$, $\lambda = 81° 07'$; Prof. E. Loomis' collections, in Sill. Jour., vol. xxxix, 1840.
	1839	3 31		Dr. Posey; reference as above.
3	1852, April 26–28	3 40.3		J. E. Hilgard, assistant Coast Survey, in $\phi = 32° 05'.0$, $\lambda = 81° 05'.1$, on Hutchinson's Island; Coast Survey Report for 1854, p. *145.
4	1857, May 1 and 2	3 27.5		C. A. Schott, assistant Coast Survey, position as above; Coast Survey Report for 1858, p. 192.
5	1874, March 8, 9, 10	1 58.5	E.	F. Blake and C. Tappan, United States Coast Survey, position on Hutchinson's Island, opposite Savannah, as above; MS. in Coast Survey archives.

Collection of Magnetic Declinations, etc.—Continued.

KEY WEST, FLA.

$\phi = 24^\circ\ 33'.5$ $\lambda = 81^\circ\ 48'.5$ W. of Gr.

(Tift's observatory.)

		° ′	
1	1829, February	6 25 E.	W. A. Whitehead; from a map of Florida, by the Topographical Engineers, of 1846.
2	1843	6 02	Report of Commander L. M. Powell, U. S. N., at custom-house.
3	1849, August 19-21	5 28.8	J. E. Hilgard, assistant Coast Survey, at Sand Key, in $\phi = 24^\circ\ 27'.2$, $\lambda = 81^\circ\ 53'.1$; Coast Survey Report for 1854, p. *145.
4	1860, February, March, June, and December.	4 46.6	Prof. W. P. Trowbridge, assistant United States Coast Survey; subsequent observer, S. Walker; Coast Survey Report for 1860, p. 340.
5	1861, February, March, April	4 44.5	Observer, S. Walker.
6	1862, monthly, May to December.	4 39.9	Observer, S. Walker.
7	1863, monthly, January to December.	4 36.8	Observer, S. Walker.
8	1864, monthly, January to December.	4 33.9	Observer, S. Walker.
9	1865, monthly, January to December.	4 31.5	Observer, S. Walker.
10	1866, January to April, inclusive.	4 29.8	Observer, S. Walker. The above observations, between 1860 and 1866, inclusive, were taken at the Coast Survey magnetic observatory at Key West, in $\phi = 24^\circ\ 33'.1$, $\lambda = 81^\circ\ 48'.5$ The results are corrected for daily variation.
11	1879, March 24, 25, 26	3 33.9 E.	Lieut.-Com'g S. M. Ackley, U. S. N., assistant Coast and Geodetic Survey; grounds of Army Hospital, $\phi = 24^\circ\ 33'.3$, $\lambda = 81^\circ\ 47'.9$

HAVANA, CUBA.

$\phi = 23^\circ\ 09'.3$ $\lambda = 82^\circ\ 21'.5$ W. of Gr.

(Morro light.)

		° ′	
	1700	6 E.	E. Halley's isogonic chart for 1700; Greenwich observations for 1869. [Not used.]
1	1726	4 24	Mathews, in $\phi = 23^\circ\ 02'$, $\lambda = 81^\circ\ 44'$; Encyc. Metrop., 1848.
2	1732, March and April	4 30	J. Harris, off Havana, in $\phi = 23^\circ\ 08'$, $\lambda = 82^\circ\ 32'$; Phil. Trans. Roy. Soc., vol. vii (abridged), 1724-34; also Encyc. Metrop., 1848.
3	1815	7 00	Encyc. Brit., seventh edition, 1842.
4	1816, August	5 30	Bentley, Encyc. Brit., seventh edition.
5	1857, January 28	5 15	Karl Friesach; Imp. Acad. of Sci., Vienna, vol. xxix, 1858.
6	1858	5 45	From a map of Cuba, 1860.
7	1879, March 13, 14, 15	3 53.8 E.	Lieut. Com'g S. M. Ackley, U. S. N., assistant Coast Survey, at the College de Belen. Annual change observed at the Colegio de Belen, according to Padre P. B. Viñes, S. J., director of observatory, 4½ minutes decreasing for several years past. [Letter of Lieut. Ackley to C. A. S., dated March 21, 1879.] The Morro light is in $\phi = 23^\circ\ 09'.3$, $\lambda = 82^\circ\ 21'.5$ Determination by Lieut. Com. F. M. Green, U. S. N.

Collection of Magnetic Declinations, etc.—Continued.

KINGSTON, PORT ROYAL, JAMAICA.

$\phi = 17^\circ\ 55'.9 \qquad \lambda = 76^\circ\ 50'.6$ W. of Gr.

(Port Royal flagstaff.)

		°	′	
	1660	6	30 E.	In Jamaica, according to J. Robertson; Phil. Trans. Roy. Soc., 1806. [Not used.]
	1700	6	30	According to Mountain's chart, constructed in the year 1700 from Dr. Halley's tables; Long's History of Jamaica; E. Halley's chart for 1700 gives 7° E.; Greenwich observations for 1869. [Not used.]
1	1732, March and April	6° to 6	05	At Black River, J. Harris; Phil. Trans. Roy. Soc., 1733.
2	1789 to 1793	6	50	J. Leard; chart of Port Royal.
	1791 to 1792	6	45	
3	1806	6	30	J. Robertson; Phil. Trans. Roy. Soc., 1806. Variation in Jamaica said to have been constant for 130 or 140 years.
4	1819	4	50	De Mackau, in $\phi = 17^\circ\ 55'$, $\lambda = 76^\circ\ 09'$; Becquerel's Traité du Magnétisme, Paris, 1846.
	1821	4	50	De Mayne, in $\phi = 17^\circ\ 55'$, $\lambda = 76^\circ\ 53'$; Becquerel, as above.
5	1822	4	54	Owen; Becquerel, as above.
6	1832	5	13	Foster; Becquerel, as above.
7	1833 (?)	4	30	From a map of Kingston of 1854.
8	1837, October	4	18	Milne, in $\phi = 17^\circ\ 56'$, $\lambda = 76^\circ\ 51'$; contributions to Terr. Mag., No. ix, by Lieut. Col. E. Sabine, Phil. Trans. Roy. Soc., 1849, part ii.
9	1847, April	3	40	Barnet, in $\phi = 17^\circ\ 56'$, $\lambda = 76^\circ\ 51'$; contributions to Terr. Mag. No. ix, by Lieut. Col. E. Sabine, Phil. Trans. Roy. Soc., 1849, part ii.
10	1857, March 2	3	40	Karl Friesach; Imp. Acad. of Sci., Vienna, vol. xxix, 1858.
	1866	4	57	English Admiralty Chart of Jamaica, No. 446. Variation in 1866 nearly stationary. [Not used.]
11	1875	4	00	Port Royal and Kingston Harbor; English Admiralty Chart, No. 456. Annual decrease 2′.
	1876	3	35 E.	West India Islands and Caribbean Sea: English Admiralty Chart No. 762. [Used mean value — 3°. 79—SCH.]

PANAMA, NEW GRANADA.

$\phi = 8^\circ\ 57'.1 \qquad \lambda = 79^\circ\ 32'.2$ W. of Gr.

(Cathedral.)

		°	′		
	1700	10		E.	Approximate value according to E. Halley's isogonic chart for 1700. Greenwich observations for 1869. [Not used; supposed to be unsupported by direct evidence.—SCH.]
1	1775, November	7	49		Encyc. Brit., 7th edition, 1842.
2	1790, October 3	7	49		Don A. Malaspina; Berliner Ast. Jahrbuch, vol. 53, for 1828, p. 188.
	1791, December	7	49		Encyc. Brit., 7th edition, 1842. [Probably same as preceding authority; not used.]
3	1802	8	00		Encyc. Brit., 7th edition, 1842.
4	1822	7	00		Hall, in $\phi = 8^\circ\ 58'$, $\lambda = 79^\circ\ 21'$; Becquerel's Traité du Magnétisme, Paris, 1846.
5	1837	7	02		Sir E. Belcher, in $\phi = 8^\circ\ 57'$, $\lambda = 79^\circ\ 29'$; Phil. Trans. Roy. Soc., 1843.
6	1849	7	15		Hughes, Brit. Admiralty Chart.
	1849	6	55		Maj. W. H. Emory, Mexican Boundary Survey, in $\phi = 8^\circ\ 57'$, $\lambda = 79^\circ\ 29'$. See also Coast Survey Report for 1856, p. 223.
7	1858	6	17		Karl Friesach; $\phi = 8^\circ\ 57'$, $\lambda = 79^\circ\ 31'$. Sir E. Sabine's Conts. to Terr. Mag., Phil. Trans. Roy. Soc., vol. 165, 1875.
8	1866, May 14	5	56		Prof. W. Harkness, U. S. N., in $\phi = 8^\circ\ 55'$, $\lambda = 79^\circ\ 30'.5$; Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
9	1873, December 25	6	57	E.	Hydrographic Office, Washington, D. C., from log-books of the Benecia and Richmond, in $\phi = 7^\circ\ 26'$, $\lambda = 79^\circ\ 54'$, off Point Mala. [Reduction to Panama, $-22'$; hence at Panama, 6° 35′ E.—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

FLORENCE, ALA.

$\phi = 34° 47'.2$ $\lambda = 87° 41'.5$ W. of Gr.

(Coast Survey station.)

		° ′	
1	1818	6 35 E.	J. H. Weakly; Prof. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838; position assigned, $\phi = 34° 50'$, $\lambda = 87° 47'$.
2	1835	6 28	
3	1865, April 17	5 24	A. T. Mosman, assistant Coast Survey; MS. in Coast Survey archives.
4	1875, May 29	5 14.4	F. E. Hilgard, Bache-Fund observer, Nat. Acad. of Sciences.
5	1881, September 5, 6	4 37.8 E.	J. B. Baylor, U. S. Coast and Geodetic Survey; $\phi = 34° 47'$, $\lambda = 87° 43'$. Grounds of College for Females.

MOBILE, ALA.

$\phi = 30° 41'.4$ $\lambda = 88° 02'.5$ W. of Gr.

(Episcopal Church.)

		° ′	
	1809	8 10 E.	J. H. Weakly, in $\phi = 30° 40'$, $\lambda = 88° 11'$; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. [Apparently more than 1½° too great. [Not used.—SCH.]
1	1814	6 30	Kent; Encyc. Brit., 7th edition, 1842; for Mobile Bay, in $\phi = 30° 13'$, $\lambda = 88° 21'$. (Longitude defective.)
2	1835	7 12	J. H. Weakly; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
3	1840	7 05	Chart of Mobile Bay, by E. and G. W. Blunt; Coast Survey Report of 1845, p. 42.
4	1843	6 56	Commander L. M. Powell, U. S. N. (in a report), at Mobile Point Light; $\phi = 30° 13'.8$, $\lambda = 88° 01'.5$; reduction to Mobile City insensible; Coast Survey Report of 1855, p. 323.
5	1847, May 21–30	7 04.1	R. H. Fauntleroy, assistant Coast Survey, at Fort Morgan, in $\phi = 30° 13'.8$, $\lambda = 88° 01'.4$; Coast Survey Report of 1854, p. *145.
6	1857, February 14–18	6 52.2	Edward Goodfellow, assistant Coast Survey, at Mobile City, near Episcopal Church, in $\phi = 30° 41'.4$, $\lambda = 88° 02'.5$; Coast Survey Report of 1858, p. 192.
7	1875, May 27	6 07.0 E.	J. M. Poole, observer for National Academy of Sciences; Bache-fund series; MS. communication.

NEW ORLEANS, LA.

$\phi = 29° 57'.2$ $\lambda = 90° 03'.9$ W. of Gr.

(Custom-house.)

		° ′	
1	1720	2 E.	Father Laval; Prof. E. Loomis' collection; Sill. Jour., vol. xxxiv, 1838.
2	1768	7 50	Gauld; Gauld's Survey of the Delta [10′ have been added to declination at Pass à Loutre to refer to New Orleans.—SCH.].
3	1796	5 06	A. G. Blanchard, city surveyor; change 2° E., from 1796 to 1870.
4	1806	8 03	Lason, from 372 observations; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
5	1840	8 20	From information in General Land Office.
6	1856, December 28	8 00	Karl Friesach; Berichte der Kais. Acad., Vienna, vol. xxix, 1858.
7	1858, April 6, 7	7 51.5	G. W. Dean, assistant United States Coast Survey; near Canal and Basin streets, $\phi = 29° 57'.4$, $\lambda = 90° 04'.4$; Coast Survey Report of 1858, p. 192.
8	1870	7 06	M. J. Thompson, State engineer.
9	1872, February 10, 12, 14, 15	6 39.6	Dr. T. C. Hilgard, observer for Bache-Fund Magnetic Survey; MS. communication, June 7, 1879; at City Park, $-6° 39'.8$; at Fair Grounds, $-6° 39'.5$.
10	1880, March 24, 25	6 27.6 E.	J. B. Baylor, U. S. Coast and Geodetic Survey; at Fair Grounds, $\phi = 29° 59'.1$, $\lambda = 90° 04'.8$

Collection of Magnetic Declinations, etc.—Continued.

VERA CRUZ, MEXICO.

$\phi = 19° 11'.9$ $\lambda = 96° 08'.8$ W. of Gr.

(Castle San Juan d'Ulloa.)

		° ′		
1	1726 to 1727	2 15	E.	Joseph Harris; Phil. Trans. Roy. Soc. (abridged), 1824–34.
2	1769	6 40		Encyc. Brit., seventh edition, 1842.
	1769, March 15	6 28		
3	1776	7 30		Don Ulloa; Encyc. Brit., seventh edition.
4	1815	10 37		Malony; Encyc. Brit., seventh edition.
5	1819, April 27	9 16		Wise; Encyc. Brit., seventh edition.
6	1839	8 22		Behard; $\phi = 19° 12'$, $\lambda = 96° 09'$; Phil. Trans. Roy. Soc., Sir E. Sabine's Conts. to Terr. Mag., No. xiv, vol. 165; 1875.
7	1856, August 7 and 8	8 17		August Sonntag, in $\phi = 19° 12'$, $\lambda = 96° 09'$, at the villa La Guaca, 200 yards south of the city; Smithsonian Contributions to Knowledge, Washington, 1860; also Coast Survey Report of 1856, p. 214.
8	1861	8 20		English Admiralty Chart No. 523, corrected to 1861.
9	1880, February 10, 11, 12	7 26.3	E.	Lieut. S. M. Ackley, U. S. N., assistant U. S. Coast and Geodetic Survey; Northeast bastion of Castle San Juan d'Ulloa, $\phi = 19° 12'.2$, $\lambda = 96° 08'.5$

CITY OF MEXICO, MEXICO.

$\phi = 19° 25'.9$ $\lambda = 99° 06'.0$ W. of Gr.

		° ′		
1	1769, June	5 20	E.	Don Alzate; Hansteen's Magnetismus der Erde, 1819.
	1769, December	5 35		Don Alzate; reference as above.
2	1775	6 42		Velasquez de Leon; Memoria del Observatorio Meteorologico Central de Mexico, Por V. Reyes, Mexico, 1880.
3	1803	8 08		Alex. von Humboldt; Hansteen's Magnetismus der Erde, 1819.
4	1849	8 30.2		Gomez de la Cortina; Memoria del Observatorio Meteorologico Central de Mexico, Por V. Reyes, Mexico, 1880.
5	1850	8 35.2		Velasquez y Terán; F. Diaz Covarrubias, Tratado de Topografia y Geodesia, México, 1869, tomo 1, p. 221.
6	1856, December 10–17	8 46		Aug. Sonntag; Observations on Terr. Mag. in Mexico, Smithsonian Contributions to Knowledge, Washington, 1860; also Coast Survey Report of 1856, p. 214.
7	1858	8 22.3		Alamazan*; F. Diaz Covarrubias' Tratado, as above.
8	1860	8 30		Salazar Ilarreguit; Tratado, as above.
9	1862	8 20.5		Diaz Covarrubias; Tratado, as above.
	1862	8 34.8		Iglesias; Memoria del Observatorio Meteorologico Central de Mexico, Por V. Reyes, Mexico, 1880.
10	1866	8 08.5		Ponce de Leon; Tratado de Topografia y Geodesia, Mexico, 1869, tomo 1, p. 221.
	1867	8 09.3		
11	1868	8 10 0		Fernandez y Diaz Covarrubias; Tratado, as above.
12	1879, September, October, November, December.	8 34.5	E.	Memoria sobre el Departamento Magnetico del Observatorio Meteorologico Central de Mexico, Por V. Reyes, Mexico, 1880.

*Almazan in Mem. del Obser'o Central.   † Llarregui in Mem. del Obser'o Central.

Collection of Magnetic Declinations, etc.—Continued.

ACAPULCO, MEXICO.

$\phi = 16° 50'.5$ $\lambda = 99° 52'.3$ W. of Gr.

(South of Fort San Diego.)

		° ′	
1	1744	3 E.	Anson; Hansteen's Magnetismus der Erde, 1819.
2	1791, April 29	7 44	Don A. Malaspina, observed on land; Berliner Astronomisches Jahrbuch, vol. 53, for 1828.
3	1822	8 40	Hall, in $\phi = 16° 50'$, $\lambda = 99° 51'$; Becquerel's Traité du Magnétisme, Paris, 1846.
4	1828	9 07	Beechey; Becquerel, as above.
5	1837	8 23	Sir E. Belcher, San Diego Fort, in $\phi = 16° 50'.9$, $\lambda = 99° 52'.2$; Admiralty Chart of Acapulco.
	1838	8 13	Sir E. Belcher; Phil. Trans. Roy. Soc., 1843.
	1838	8 17	Du Petit Thouars; Voyage of the Frigate Venus.
	1841	8 17	Duflot de Mofras' Exploration of Oregon, Paris, 1844. [Probably Du Petit Thouars' value; not used.]
6	1866, May 30	8 22	W. Harkness, Prof. U. S. N., in $\phi = 16° 50'.1$, $\lambda = 99° 52'.3$; Observations on Terr. Mag., Smithsonian Contributions to Knowledge, No. 239, 1873, p. 61.
7	1874, March 17	8 38.7	G. Dewey, Commander U. S. Steamer Narragansett; Lieuts. Z. L. Tanner and E. J. Young, observers, in $\phi = 16° 50'.5$, $\lambda = 99° 55'.4$
8	1880, November 23, 24	7 56.6 E.	H. E. Nichols, Lieut. U. S. N., act'g assist. U. S. Coast and Geodetic Survey, Cocoanut Grove, close to Professor Harkness' station of 1866; in $\phi = 16° 49'.2$, $\lambda = 99° 56'.3$

SAN BLAS, MEXICO.

$\phi = 21° 32'.6$ $\lambda = 105° 15'.7$ W. of Gr.

		° ′	
1	1791, April 12	7 28 E.	Don A. Malaspina, observed on shore; Berliner Ast. Jahrbuch, vol. 53, for 1828; also Encyc. Brit., seventh edition, 1842.
2	1821–22	8 40	Hall; Encyc. Brit., seventh edition.
	1828	11 06	Beechey; Beechey's Voyage to the Pacific, 1825–28; also Becquerel's Traité du Magnétisme, Paris, 1846. [Not used.]
3	1837	8 34	Sir E. Belcher; in $\phi = 21° 32'$, $\lambda = 105° 16'$; Phil. Trans. Roy. Soc., 1843.
	1837	9 09	Voyage de la Vénus, Paris, 1841. Gen. Sir E. Sabine's Conts. to Terr. Mag.; Phil. Trans. Roy. Soc., No. xiv, vol. 165, pt. 1, 1875. Position, $\phi = 21° 32'$, $\lambda = 105° 16'$.
4	1838	8 47	Sir E. Belcher in the Sulphur. Reference as above.
5	1839	9 00	Sir E. Belcher; Phil. Trans. Roy. Soc., 1843.
6	1841	9 12	Duflot de Mofras' Exploration of Oregon, Paris, 1844.
7	1874, February 23, 24, 26	9 08.2	G. Dewey, Commander U. S. Steamer Narragansett; Lieuts. Z. L. Tanner and E. J. Young, observers, in $\phi = 21° 32'.4$, $\lambda = 105° 18'.7$
8	1880, December 5	9 18.1 E.	H. E. Nichols, Lieut. U. S. N., act'g assist. U. S. Coast and Geodetic Survey, near custom-house, station of Sir E. Belcher of 1839; in $\phi = 21° 32'.2$, $\lambda = 105° 18'.1$

MAGDALENA BAY, LOWER CALIFORNIA.

$\phi = 24° 38'.4$ $\lambda = 112° 08'.9$ W. of Gr.

(Near village on Man of War Cove.)

		° ′	
1	1837	8 15 E.	Du Petit Thouars; Voyage of the Frigate Venus.
		8 17	Frigate Venus — Gen. Sir Edward Sabine in Phil. Trans. Roy. Soc., vol. 165, pt. 1, 1875. Conts. to Terr. Mag., No. xiv.
2	1839	9 15	Sir Edward Belcher, in $\phi = 24° 38'$, $\lambda = 112° 07'$. — Gen. Sir Edward Sabine in Phil. Trans. Roy. Soc., vol. 165, pt. 1, 1875. Conts. to Terr. Mag., No. xiv.
	1841	8 15	Duflot de Mofras; Exploration of Oregon, Paris, 1844; in $\phi = 24° 36'$, $\lambda = 112° 05'$. [Not used.]
3	1866, June 9	10 40.5	W. Harkness, Prof. U. S. N.; cruise of the Monadnock, 1865–'66. Smithsonian Contributions to Knowledge, No. 239, Washington, 1873; in $\phi = 24° 40'$, $\lambda = 112° 07'$.
4	1871, March to June	11 00	G. Bradford, assistant Coast Survey; near village on Man of War Cove; in $\phi = 24° 37'.5$, $\lambda = 112° 13'.3$ Chart in Coast Survey archives.
5	1873, March 5, 6, 7	10 36.6	W. Eimbeck, assistant Coast Survey; near village, on Man of War Cove; in $\phi = 24° 38'.4$, $\lambda = 112° 08'.9$ [Near Belcher's and Bradford's stations.] Record in Coast Survey archives.
	1873, June 23	10 30.8	G. Dewey, Commander U. S. Steamer Narragansett; Lieuts. Z. L. Tanner and E. J. Young, observers.
6	1881, February 24	10 29.1 E.	H. E. Nichols, Lieut. Com'r U. S. N., act'g assist. U. S. Coast and Geodetic Survey, at Assistant Eimbeck's station of 1873; in $\phi = 24° 38'.4$, $\lambda = 112° 08'.9$

Collection of Magnetic Declinations, etc.—Continued.

SAN DIEGO, CAL.

$\phi = 32° 42'.1$ $\lambda = 117° 14'.3$ W. of Gr.

(La Playa, Point Loma.)

		° ′		
1	1792	11	E.	Vancouver; in $\phi = 32° 39'$, $\lambda = 117° 17'$; Capt. G. Vancouver's Voyage of Discovery, etc., 1790–95, vol. 2, p. 475, London, 1798; also Hansteen's Magnetismus der Erde, 1819.
	1793, December	11		Reference as above; in $\phi = 32° 42'$, $\lambda = 116° 53'$. Observed on board ship on or near the coast. [Not used.]
2	1839	12 20.6		Sir E. Belcher; in $\phi = 32° 41'$, $\lambda = 117° 13'$; Phil. Trans. Roy. Soc., 1841.
	1841	11		Duflot de Mofras; Exploration of Oregon, Paris, 1844; in $\phi = 32° 39'.5$, $\lambda = 117° 17'$. [Not used.]
3	1851, April 28 to May 7	12 28.8		G. Davidson, assistant Coast Survey; near La Playa, in $\phi = 32° 42'.2$, $\lambda = 117° 14'.6$; Coast Survey Report of 1856, p. 229.
4	1853, October 15	12 31.7		Lieut. W. P. Trowbridge, assistant Coast Survey; at La Playa, near the custom-house; Coast Survey Report of 1856.
5	1866, June 15	13 09.4		W. Harkness, Prof. U. S. N.; in $\phi = 32° 42'$, $\lambda = 117° 13'$, at La Playa; Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
	1871, May 28–30	14 46.7		G. Davidson, assistant Coast Survey; at New San Diego, in $\phi = 32° 43'.1$, $\lambda = 117° 09'.7$; MS. in Coast Survey archives. [Not used; distance from La Playa too great, reduction uncertain.]
6	1872, November 19–21	13 19.4		G. Davidson and S. R. Throckmorton, United States Coast Survey; near La Playa, in $\phi = 32° 42'.2$, $\lambda = 117° 14'.6$, station of 1851; MS. in Coast Survey archives.
	1879	12 55		Capt. W. A. Jones; from a plan of New San Diego, showing U. S. barracks. [Not used.—SCH.]
7	1881, April 6	13 27.6	E.	H. E. Nichols, Lieut. Com'r U. S. N., act'g assist. Coast and Geodetic Survey; at Assistant Davidson's station of 1851; in $\phi = 32° 42'.2$, $\lambda = 117° 14'.5$

MONTEREY AND POINT PINOS, CAL.

$\phi = 36° 36'.1$ $\lambda = 121° 53'.6$ W. of Gr.

(Custom-house.)

		° ′		
1	1786, September 14, 15	11 48	E.	La Perouse (J. F. G. de); at sea, a few miles from the anchorage, declination 11° 57′, and twenty miles N. and W. from Point Pinos, 11° 39′. Voyage, etc., Paris, 1797, vol. 3, p. 302 and p. 390. Communicated by Mr. M. Baker.
2	1791, September 23	10 56		Don A. Malaspina; Berliner Ast. Jahrbuch, vol. 53, for 1828. Observation made on shore.*
	1972, December	12 22		Vancouver; in $\phi = 36° 36'$, $\lambda = 121° 34'$; Capt. G. Vancouver's Voyage of Discovery, etc., 1790–95, vol. 2, p. 51, London, 1798; also Hansteen's Magnetismus der Erde, 1819. [Not used.]
3	1794, November 13	12 22		Vancouver; in $\phi = 36° 36'$, $\lambda = 121° 51'$; Capt. G. Vancouver's Voyage of Discovery, etc., vol. iii, p. 337; also Hansteen's Magnetismus der Erde, 1819. Probably taken on shore.
	1818, September	16 30		Captain Golovnin (V. M.); apparently at Presidio, in $\phi = 36° 36'.2$. Voyage around the World, St. Petersburg, 1822, vol. 2. Communicated by Mr. M. Baker. [Not used; apparently about 3° in error.—SCH.]
	1827	15 38		Beechey; Phil. Trans. Roy. Soc., vol. 165, 1875; Sir E. Sabine's Conts. to Terr. Mag., No. xiv. [Not used.]
4	1837	14 30		Du Petit Thouars; Voyage of the Frigate Venus; near Monterey.
5	1839	14 13		Sir E. Belcher; in $\phi = 36° 36'$, $\lambda = 121° 53'$; Phil. Trans. Roy. Soc., 1841.
6	1841	15 00		Duflot de Mofras; Exploration of Oregon, Paris, 1844; at Presidio, Monterey, in $\phi = 36° 36'$, $\lambda = 121° 53'$
7	1843	14 00		Chart of the harbor of Monterey, surveyed by Commander T. A. Dornin; position of fort, $\phi = 36° 36'.4$, $\lambda = 121° 52'.4$
8	1851, February 8	14 58.3		G. Davidson, assistant Coast Survey; at Point Pinos astronomical station, $\phi = 36° 37'.8$, $\lambda = 121° 55'.5$; Coast Survey Report for 1856, p. 229.
9	1854, May 29, 30	14 58.9		W. P. Trowbridge, Lieut. U. S. A., assistant Coast Survey. Station near Barracks of Redoubt, in $\phi = 36° 36'.2$, $\lambda = 121° 53'.8$
10	1873, August 30, 31, September 1	15 55.3		G. Davidson and S. R. Throckmorton, United States Coast Survey; near astronomical station, in $\phi = 36° 37'.8$, $\lambda = 121° 55'.6$; MS. in Coast Survey archives.
11	1881, April 20	15 53.9	E.	H. E. Nichols, Lieut. Com'r U. S. N., act'g assist. Coast and Geodetic Survey; near Lieutenant Trowbridge's station of 1854, in redoubt, $\phi = 36° 36'.2$, $\lambda = 151° 53'.8$

* The Coast Survey Report for 1856, p. 229, gives the erroneous date 1790.

Collection of Magnetic Declinations, etc.—Continued.

SAN FRANCISCO, CAL.

$\phi = 37° 47'.5$ $\lambda = 122° 27'.2$ W. of Gr.

(Presidio.)

		° ′		
1	1792, November 20	12 48	E.	Vancouver; in $\phi = 37° 48'$, $\lambda = 122° 07'.5$; Vancouver's Voyage, 1798, vol. 2, p. 27. Taken on board ship. Values varying from 12° 02′ to 13° 32′.*
	1816, October	16 05		Kotzebue's Voyage of Discovery, 1815–18; in $\phi = 37° 48'.6$, $\lambda = 122° 12'.5$ [Not used.]
2	1818, September 20 (O. S.)	15 00		Captain Golovnin (V. M.); Voyage around the World, St. Petersburg, 1822, vol. 2.*
	1824	16 00		Kotzebue. [Not used.] } Becquerel's Traité du Magnétisme, Paris, 1846.
3	1827	15 27		Beechey } Becquerel's Traité du Magnétisme, Paris, 1846.
4	1829, December 6	14 55		Erman (A. G.); Reise um die Erde, Berlin, 1835, vol. 1.
5	1830	14 51		Erman; Phil. Trans. Roy. Soc., vol. 165, 1875; Sir E. Sabine's Conts. to Terr. Mag., No. xiv.
6	1837	15 20		Sir E. Belcher; in $\phi = 37° 48'$, $\lambda = 122° 23'$; Phil. Trans. Roy. Soc., 1841.
6	1837	15 00		Du Petit Thouars; Voyage of the Frigate Venus.
7	1839	15 20		Sir E. Belcher; in $\phi = 37° 48'$, $\lambda = 122° 23'$; Phil. Trans. Roy. Soc., 1841.
8	1841, October	15 30		Duflot de Mofras; Exploration of Oregon, Paris, 1844; in $\phi = 37° 48'.5$, $\lambda = 122° 28'.4$
8	1842, January	15 30		Duflot de Mofras; as above; at Fort Point.
9	1849–50	15 40.8		Ringgold, Commander U. S. N., at Alcatraz Island, harbor of San Francisco.
10	1852, February 18–28	15 27.6		G. Davidson, assistant Coast Survey; in $\phi = 37° 47'.5$, $\lambda = 122° 27'.2$; at Presidio; mean of daily maximum and minimum; Coast Survey Report, 1856, p. 229, and MS. in Coast Survey archives; mean, 15° 28′.8 E.
10	1852, March 24	15 28.8		
10	1852, April 21	15 27.8		
10	1852, May 28	15 31.1		
11	1858, June 3–8	15 49.4		Karl Friesach; Reports Imp. Acad. of Sciences, Vienna, 1860, vol. 38; Dupont street, near Catholic church; $\phi = 37° 47'.8$, $\lambda = 122° 24'.0$ Second set of observations corner Stockton and California streets; mean value, 15° 52′.8 E.
11	1858, June 10–12	15 56.2		
12	1866, June 26	16 25.5		W. Harkness, Prof. U. S. N.; in $\phi = 37° 49'$, $\lambda = 122° 21'$; east side of Yerba Buena Island; Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
13	1871, December 14, 15, 16	16 23.1		G. Davidson and S. R. Throckmorton, United States Coast Survey; at Presidio station of 1852; MS. in Coast Survey archives.
14	1872, October 26, 27, 28	16 25.7		Reference as above.
15	1873, June 25, 26, 27	16 25.4		
15	1873, August 19, 20, 21, 22, 23	16 24.0		
15	1873, November 12 to 16	16 25.4		G. Davidson and W. Eimbeck, United States Coast Survey; at Presidio; MS. in Coast Survey archives. Mean for 1873.7, 16° 24′.8
16	1874, January 10, 12, 13, 14; 1874, February 19, 20, 21	16 26.9		Reference as above.
17	1879, March 12, 13, 14, 15	16 34.0		G. Davidson and B. A. Colonna, assistants United States Coast Survey; at Presidio astronomical station.
18	1880, September 25, 26	16 28.3		H. E. Nichols, Lieut. U. S. N., act'g assist. Coast and Geodetic Survey; at the Presidio station.
18	1880, November 20	16 39.5		W. H. Dall and M. Baker, United States Coast and Geodetic Survey; at the Presidio station. Mean value, − 16° 33′.9, for epoch 1880.81
19	1881, March 30, 31, April 1	16 33.3		W. Eimbeck, assistant Coast and Geodetic Survey; at Presidio.
19	1881, April 26, 27	16 31.9		H. E. Nichols, Lieut. Com'r U. S. N., act'g assist. Coast and Geodetic Survey; at the Presidio station.
19	1881, July 12, November 1	16 32.2		
19	1881, June 22, 23, 24, December 1, 2, 3.	16 18.2	E.	J. S. Lawson, assist. Coast and Geodetic Survey; at Presidio. Mean of four values, − 16° 28′.9, for 1881.48

* Communicated by Mr. M. Baker, United States Coast and Geodetic Survey.

Collection of Magnetic Declinations, etc.—Continued.

CAPE DISAPPOINTMENT, COLUMBIA RIVER, WASHINGTON TERRITORY.
$\phi = 46° 16'.7$ $\lambda = 124° 02'.0$ W. of Gr.
(South shore of Baker's Bay.)

		° ′	
1	1786, September 1, 2	18 0 E.	La Perouse (J. F. G. de); observed at sea, on the Boussole, Sept. 1, in $\phi = 46° 39'$, $\lambda = 124° 17'$, declination 18° 53′ E., and Sept. 2, in $\varphi = 45° 57'$, $\lambda = 124° 10'$, declination 17° 07′. *Voyage autour du monde, etc., Paris, 1797, vol. iii, pp. 300, 305, 388.* Communicated by Mr. M. Baker.
2	1792, April 27	18	Vancouver;* in $\phi = 46° 14'$, $\lambda = 123° 59'$, near mouth of Columbia River; Hansteen's Magnetismus der Erde, 1819.
	1792, December	20	Vancouver's voyage;† reference as above; in $\phi = 46° 19'$, $\lambda = 123° 53'$. [Value evidently too high; not used.]
3	1839	19 11	Sir E. Belcher; in $\phi = 46° 17'$, $\lambda = 124° 02'$; Phil. Trans. Roy. Soc., 1842; on Baker's Bay.
4	1842	20 00	Duflot de Mofras; Exploration of Oregon, Paris, 1844; at mouth of Columbia River.
5	1851, July 5–9	20 19.1	G. Davidson, assistant Coast Survey; in $\phi = 46° 16'.7$, $\lambda = 124° 02'.0$, near beach of Baker's Bay, Cape Disappointment; Coast Survey Report of 1856, p. 230.
	1851, July 14–19	20 45.3	Reference as above; on top of cape, in $\phi = 46° 16'.6$, $\lambda = 124° 02'.0$, at astronomical station.
6	1858	21 00	Communication by S. Garfielde, surveyor-general Washington Territory, dated August 24, 1866.
7	1873, October 24–27	21 26.5	W. Eimbeck, United States Coast Survey; near beach of Baker's Bay, in $\phi = 46° 16'.7$, $\lambda = 124° 02'$; MS. in Coast Survey archives.
	1873, October 19–23	21 46.9	W. Eimbeck, United States Coast Survey; at old astronomical station, top of cape; MS. in Coast Survey archives. [Not used.—SCH.]
8	1881, October 14	21 36.0 E.	H. E. Nichols, Lieut. Com'r U. S. N., act'g assist. Coast and Geodetic Survey; near beach, station of 1873.

* Vancouver's observations, made on board ship. † Observation by Broughton.

NEE-AH BAY, STRAIT OF JUAN DE FUCA, WASHINGTON TERRITORY.
$\phi = 48° 21'.8$ $\lambda = 124° 38'.0$ W. of Gr.
(Scarborough Harbor, Astronomical Station.)

		° ′	
1	1792, April 30	18 00 E.	Vancouver; Hansteen's Magnetismus der Erde, 1819. Inside Cape Flattery, $\phi = 48° 19'$, $\lambda = 123° 41'$ (possibly misprint for 124° 41′).
2	1841	22 30	Chart of U. S. Exploring Expedition, Commander Wilkes; Scarborough Harbor, north point Nee-ah Island. $\phi = 48° 21'.8$, $\lambda = 124° 38'.0$
3	1852, August 17, 18, 19, 20, 21, 22, 23	21 29.9	G. Davidson, assistant Coast Survey, and J. Rockwell, Coast Survey; Scarborough Harbor, astronomical station, in $\phi = 48° 21'.8$, $\lambda = 124° 38'.0$
4	1855, August 13, 15, 16, 18	21 48.2	Lieut. W. P. Trowbridge, assistant Coast Survey; Nee-ah Bay, near Wa-addah Island.
5	1881, October 11	22 44.2 E.	H. E. Nichols, Lieut. Com'r U. S. N., act'g assist. Coast and Geodetic Survey; near station of 1855.

NOOTKA, VANCOUVER ISLAND.
$\phi = 49° 35'.5$ $\lambda = 126° 37'.5$ W. of Gr.
(Friendly Cove.)

		° ′	
1	1778, April 4	19 45 E.	Cook; in Resolution Cove, $\phi = 49° 35'$, $\lambda = 126° 37'$; Hansteen's Magnetismus der Erde, 1819; also Encyc. Metrop., 1848,*
2	1786, August 25, 26	21 30	La Perouse (J. F. G. de); Voyage, etc., Paris, 1797, vol. iii, pp. 300, 310, and 388. Observed about ten miles off shore on board the Astrolabe, in average $\phi = 49° 39'$, and average $\lambda = 128° 39'$; declination, 19° 47′ E. On board the Boussole, in average $\phi = 49° 37'$, and average $\lambda = 127° 22'$; declination, 23° 14′ E. Mean adopted in table. Communicated by Mr. M. Baker.
3	1791, August 16, 17, September 4	22 30	Don A. Malaspina; observed on shore; Berliner Astronomisches Jahrbuch, vol. 53, for 1828. Sept. 4, 1791, in $\phi = 49° 57'$, $\lambda = 126° 19'$. See Et. Marchand's voyage autour du Monde, Paris, an VII., vol. 2.
4	1792, October	18 22	Vancouver; in $\phi = 49° 34'$, $\lambda = 126° 28'$ in Nootka Sound; Hansteen's Magnetismus der Erde, 1819.
5	1860	23 47	G. H. Richards, Capt. R. N.; in Friendly Cove, $\phi = 49° 35'.5$, $\lambda = 126° 37'.5$; Vancouver Island Pilot, Admiralty, London, 1864.
6	1863	23 05	G. H. Richards, Capt. R. N.; in Friendly Cove, $\phi = 49° 35'.5$, $\lambda = 126° 37'.5$; Admiralty Chart of Nootka Sound, No. 1916, 1865; magnetic variation increasing about 2′ annually.
7	1881, September 27	23 36.2 E.	H. E. Nichols, Lieut. Com'r U. S. N., act'g assist. Coast and Geodetic Survey; at Friendly Cove.

*Cook notes large local attractions on shore at Ship Cove; vol. 2, p. 338, of his voyage to the Pacific, London, 1784; tabular value as observed on board ship.

Collection of Magnetic Declinations, etc.—Continued.

KAILUA (KAIRUA), HILO AND KEALAKEKUA (KARAKAKOA) BAYS, ISLAND OF HAWAII (OWHYHEE), SANDWICH ISLANDS.

$\phi = +19^\circ 37'$ $\lambda = 156^\circ 01'$ W. of Gr.

(Kailua Bay.)

		° ′		
1	1779	8 06	E.	Cook; in $\phi = 19^\circ 28'$, $\lambda = 156^\circ 00'$ W. of Gr.; P. Barlow, in Encyc. Metropol., London, 1848.
2	1791, Oct. 4, 8	8 02		Capt. Et. Marchand. West of Hawaii. Voyage autour du monde, Paris an vii, vol. 2. October 4, declination 8° 00′ E. in $\phi = 19^\circ 13'$, $\lambda = 154^\circ 34'$; October 8, declination 8° 05′ E. in $\phi = 19^\circ 19'$, $\lambda = 157^\circ 22'$.
3	1793, March	7 47		Capt. G. Vancouver; A Voyage of Discovery, 1790 to 1795, vol. 2, p. 170, London, 1798. At Hilo.
4	1796, January	8 44		Broughton (W. R.); A Voyage of Discovery, etc., London, 1804, in $\phi = 19^\circ 28'.2$, $\lambda = 156^\circ 02'.2$: mean of three compasses on ship and on shore. See also Encyc. Metropol., London, 1848.
	1796	9 12		Broughton; Encyc. Metropol., London, 1848. [Not used.]
	1818, October	7 30		Captain V. M. Golovnin, at Kairua Bay; Voyage around the world. St. Petersburg, 1822, vol. 2. [Not used.—SCH.]
5	1819	9 50		Freycinet; at Kawaihae; $\phi = 20^\circ.5$; NW. Hawaii.
6	1824	10 14		Byron; Island of Owhyhee, in $\phi = 19^\circ 43'$, $\lambda = 156^\circ 10'$. Gen. Sir E. Sabine's Conts. to Terr. Mag., No. xiv, in Phil. Trans. Roy. Soc., vol. 165, pt. 1, 1875.
7	1825	8 51		Byron. At Hilo.*
	1836	7 43		Voyage de la Venus, Paris, 1841. Position and reference as above for 1824. [Not used.]
8	1841	8 50		Com. Wilkes, U. S. N. At Hilo.*
9	1853	8 15		C. J. Lyons; Haw. Government Survey. On shore at Kawaihae.* N. B.—The British Admiralty Chart No. 782 gives the declination for 1875, 9° 15′ E.
10	1877	8 10	E.	C. J. Lyons; Haw. Government Survey. In Hamakua and North Hilo, NE. coast of Hawaii. Reported to W. D. Alexander, Superintendent Government Survey. [10′ may be subtracted to refer to latitudes of Hilo and Kailua.—SCH.]

* Communication by W. D. Alexander, December 11, 1877.

HONOLULU, ISLAND OF OAHU (WOAHOO), SANDWICH ISLANDS.

$\phi = +21^\circ 18'.2$ $\lambda = 157^\circ 55'.0$ W. of Gr.

(Fort near town.)

		° ′		
1	1792, March	7 50	E.	Vancouver; observed on board ship, at anchor, in Whyteete Bay in $\phi = 21^\circ 16'.8$, $\lambda = 157^\circ 50'.4$ Voyage Around the World, London, 1798, vol. 1.†
	1793	5 52		Capt. G. Vancouver. At Waikiki, S. of Honolulu.* [Not used.]
2	1796, February	9 41		Broughton (Lieut. W. R.), Whyteete Bay, $\phi = 21^\circ 18'$, $\lambda = 157^\circ 59'.5$ A Voyage of Discovery, London, 1804.†
3	1816	10 57		Kotzebue. At Honolulu.*
4	1819	10 24		Capt. Freycinet. At Honolulu.*
5	1824, ('25)	9 52		Byron; from L. S. Kaemtz MSS. } Oahu Island, in $\phi = 21^\circ 17'$, $\lambda = 158^\circ 00'$. Gen. Sir E. Sabine's Conts. to Terr. Mag., No. xiv, Phil. Trans. Roy. Soc., vol. 165, pt. 1, 1875.
6	1827	10 26		Beechey; from L. S. Kaemtz MSS. }
7	1836	10 11		Voyage de la Bonite, Paris, 1842. } Honolulu, in $\phi = 21^\circ 19'$, $\lambda = 157^\circ 48'$. Gen. Sir E. Sabine, in Phil. Trans., as above.
8 {	1837	10 00		Voyage de la Venus, Paris, 1841. }
	1837	10 39		Beechey ... } Oahu Island. Reference as above.
9	1838	10 39		Belcher .... }
10	1840	9 17		Berghaus; from L. S. Kaemtz MSS } Honolulu.
	1841	8 15		Com. Wilkes, U. S. N. At Honolulu.* [Not used.] } Honolulu.
	1852	9 10		Collinson; MS. in British Hydrographic Office. Reference as above. [Not used.] } Honolulu.
11	1859, January, February, March.	9 41		Karl Friesach; Memoirs of the Imperial Academy of Sciences, vol. xxix to xliv. Reference as above. In $\phi = 21^\circ 18'.6$, $\lambda = 157^\circ 48'.9$
	1867, August	11 15		W. Reynolds, Capt. U. S. N., in the Lackawanna (chart No. 6). Wharf near court-house, in $\phi = 21^\circ 18'.2$, $\lambda = 157^\circ 50'.1$ W. of Gr. [Not used.]
12	1871	9 36		C. J. Lyons; Haw. Government Survey. North side entrance to Honolulu Harbor.*
13	1872	9 18		C. J. Lyons; Haw. Government Survey. South side of entrance, on Fisherman's Point.*
14 {	1875	9 16		W. D. Alexander. Entrance of Pearl Lochs, Oahu, and throughout Ewa District.*
	1875	9 15	E.	W. D. Alexander. Shore at Waikiki, south of Honolulu.*

* These observations were communicated to the Superintendent of the Coast Survey by W. D. Alexander, superintendent of the Hawaiian Government Survey, in a letter dated Mikawao, Maui, Hawaiian Islands, December 11, 1877.

† Communicated by Mr. M. Baker, United States Coast and Geodetic Survey.

Collection of Magnetic Declinations, etc.—Continued.

SITKA, ALASKA.

$\phi = 57° 02'.9$ $\lambda = 135° 19'.7$ W. of Gr.

(Parade Grounds, Sitka.)

No.	Date	°	′		Authority
	1775, August 23	22		E.	F. A. Maurelle; Journal of a Voyage to NW. coast of America; D. Barrington, Miscellanies, London, 1781. $\phi = 57° 08'$, at sea, near coast. [Not used.—SCH.]
1	1786, August 6, 7	26	46		La Perouse, (J. F. G. de) Voyage, etc., Paris, 1797, vol. iii, pp. 296, 299, 386. Mean of four determinations observed a few leagues off shore. On board the Boussole 28° 28′ E., in average $\phi = 56° 54'$ and average $\lambda = 135° 26'$. On board the Astrolabe, about the same places, 25° 04′ E.
2	1787, June	24			Capt. G. Dixon; Voyage round the World, London, 1789. At anchor near White's Point, $\phi = 57° 03'$, $\lambda = 135° 38'$ [compass bearing].
3	1791, August 8, 11, 21	27	46		Capt. E. Marchand; Voyage round the World, London, 1801, 2 vols. Mean of 3 values given in vol. ii. One mile north of above station, in $\phi = 57° 04'$, $\lambda = 137° 59'$ (from Paris). In vol. i observer gives 28° 45′.
4	1804, August 20	26	45		Capt. U. Lisiansky; Voyage round the World, London, 1814, $\phi = 57° 03'$, $\lambda = 135° 30'$.
5	1818, July	27	15		Capt. V. M. Golovnin; Voyage round the World, St. Petersburg, 1822, vol. ii. Mean of several observations between 24° and 30½ E. In $\phi = 57° 02'.8$, $\lambda = 135° 06'.6$
6	1824, August	27	30		Capt. Otto von Kotzebue; New Voyage round the World, 1823-26; 8°. London, 1830, vol. ii, pp. 66, 77. In $\phi = 57° 02'.9$, $\lambda = 135° 33'.3$
7	1827.5	28	50		Capt. F. P. Lütke; Gen. Sir E. Sabine's Conts. to Terr. Mag., Phil. Trans. Roy. Soc., 1872, No. xiii. In $\phi = 57° 03'$, $\lambda = 135° 23'$.
8	1829, November 10	28	18.8		Ad. Erman; Reise um die Welt, Berlin, 1835, vols. i and ii. A careful determination on shore, behind the church, in $\phi = 57° 02'.7$, $\lambda = 137° 45'.7$ (from Paris).
9	1837, September 12-16	27	42		Sir E. Belcher; Sir E. Sabine in Phil. Trans. Roy. Soc., 1841, part i. In $\phi = 57° 03'$, $\lambda = 135° 26'$; a careful determination on shore, near governor's house.
	1839, July 15-19	29	32.5		Sir E. Belcher; Sir E. Sabine, in Phil. Trans. Roy. Soc., 1843, part i. In $\phi = 57° 03'$, $\lambda = 135° 22'$, at summer-house in governor's garden. A careful determination. [Mean of these 2 determinations used, viz, for 1838.6, − 28°.62—SCH.]
10	1842, every month except January, February, and October.	28	32.4		At Magnetic Observatory, Japonski Island, founded in 1842. Hourly observations. In $\phi = 57° 02'.9$, $\lambda = 135° 20'.1$ Annuaire Mét. et Mag. du Corps des Mines de Russie, St.-Pétersbourg, 184- to 184-.
11	1843, January to December	28	54.0		
12	1844, January to December	28	57.3		
13	1845, January to December	29	00.0		
14	1847, May to December	28	58.9		At Magnetic Observatory, Japonski Island; Annales des l'Observ. phys. Central du Russie, St.-Pétersbourg, 184- to 185-.
15	1848, January to December	29	04.5		
16	1849, January, February, March.	29	03.6		
17	1850, January to December	28	50.3		
	1851.0	29	14		Capt. Richard Collinson; MS. in Brit. Hyd. Off.; Sir E. Sabine in Phil. Trans. Roy. Soc., 1872; Conts. to Terr. Mag., No. xiii. [Not used.—SCH.]
18	1851, whole year	28	53.1		See differential observations at Magnetic Observatory, Japonski Island. Compte-Rendu of the Central Physical Observatory of Russia, 1851 to 1864. In 1851-52-56 observations during seventeen hours each day. In 1857-58-59-60-61-63-64 observations during nineteen hours each day. Hourly observations in 1862. Mr. Marcus Baker discussed the differential observations taken at Japonski Island between 1850 and 1864, inclusive, and finding no absolute determination for this period based the annual mean values upon the computed value from formula given in the fourth edition of this paper, viz: 29° 07′.2 for 1857.5, corresponding to 396.0 of differential scale reading. [March, 1882. -SCH.]
19	1852, January to July, November and December.	28	48.5		
20	1856	28	58.6		
21	1857, whole year	29	07.2		
22	1858, whole year	29	10.5		
23	1859, whole year	29	06.1		
24	1860, whole year	29	07.9		
25	1861	29	04.1		
26	1862, whole year	29	00.9		
27	1863	29	03.3		
28	1864	29	04.2		
29	1867, August 17, 18, 19, 20	28	49		A. T. Mosman, assistant U. S. Coast Survey; at old Russian observatory on Japonski Island, Harbor of Sitka; in $\phi = 57° 02'.9$, $\lambda = 135° 20'.1$; Coast Pilot of Alaska, by the U. S. Coast Survey, 1869, p. 120.
30	1874, May 4, 5	28	59.5		M. Baker, U. S. C. S. observer; W. H. Dall, acting asst. C. S. in charge of party; station on Parade Ground, in $\phi = 57° 02'.9$, $\lambda = 135° 19'.7$; MS. in Coast Survey archives.
31	1876, January 15 to March 20	28	20.5		Capt. J. B. Campbell and Lieut. W. R. Quinan, U. S. A.; Report of Chief of Engineers, 1876, part 3, p. 751.
32	1879, April	28	54		Lieut. J. E. Craig, U. S. S. Alaska; report to Capt. G. Brown, U. S. N., May 7, 1879; at Coast Survey station.
33	1880, May 17-18	29	04.8		M. Baker and W. H. Dall, U. S. Coast and Geodetic Survey, near old Russian observatory on Japonski Island, in $\phi = 57° 02'.9$, $\lambda = 135° 20'.3$
34	1881, September 15-16	29	11.2	E.	H. E. Nichols, Lieut.-Com'r U. S. N.; acting asst. Coast and Geodetic Survey. On Japonski Island.

N. B.—For the collection of the values Nos. 0, 1, 2, 3, 5, and 10 to 28, inclusive, I am indebted to Mr. Marcus Baker, of the Computing Division, Coast and Geodetic Survey Office. He discussed the hourly differential observations made at the Magnetic Observatory between 1842 and 1849, basing the annual means upon the absolute determinations, January 4, 1843, D = − 28° 48′ 54″ and March 4, 1843, D = − 28° 57′ 20″; the first corresponding to 419.3, the second to 432.4, scale divisions of the differential declinometer.—SCH.

Collection of Magnetic Declinations, etc.—Continued.

PORT MULGRAVE, YAKUTAT BAY, ALASKA.

$\phi = 59° 33'.7$ $\lambda = 139° 45'.9$ W. of Gr.

		° ′	
1 {	1778, May 6	23 10 E.	Cook; Voyage to the Pacific Ocean, 4°. London, 1784, vol. 3, p. 506.
	1778, May 7	24 26	May 6, at sea, off Dry Bank, in $\phi = 59° 08'$, $\lambda = 139° 41'$. May 7, at sea, near coast S. of Mt. Elias, $\phi = 59° 27'.5$, $\lambda = 140° 53'$. [Mean $\phi = 59° 18'$, mean $\lambda = 140° 17'$; taking the mean we have for 1778.3 the declination $- 23°.80$, to which the weight ½ is given in the discussion.—SCH.]
2	1787, May	26 00	Dixon; Voyage, etc., 4to, London, 1789.
3	1791, July 1	26 40	Malaspina, in Bode's Berliner Jahrbuch for 1828; also Espinoza Memorias, 2 vols., 4to, Madrid, 1809. On shore, in $\phi = 59° 33'.7$, $\lambda = 139° 46'.3$
4	1794, July	26 00	Vancouver; Voyage, etc., 3 vols., 4°. London, 1798. Port Mulgrave, Puget, observer, with ship compass.
5	1802 (about)	29 00	At New Russia Harbor, settled 1795 and destroyed 1803, in $\phi = 59° 31'$, $\lambda = 139° 36'.5$ Old Russian chart, without date or author.
6	1823	30 30	Lieut. Khromchenko, on Russian Hydc. chart, 1378. End of spit in $\phi = 59° 33'.6$, $\lambda = 139° 46'.5$
7	1874, May 22	29 58.3	M. Baker, U. S. Coast Survey, observer. [W. H. Dall, chief of party.]
8	1880, June 24	29 59.8 E.	M. Baker and W. H. Dall, U. S. Coast and Geodetic Survey; at Port Mulgrave, Yakutat Bay, in $\phi = 59° 33'.7$, $\lambda = 139° 45'.9$

N. B.—For Nos. 1, 4, and 5 of the above table of results I am indebted to Mr. M. Baker, of the Coast and Geodetic Survey.

PORT ETCHES, PRINCE WILLIAM SOUND, ALASKA.

$\phi = 60° 20'.7$ $\lambda = 146° 37'.6$ W. of Gr.

(Astronomical station of 1874.)

		° ′	
1	1778, May 19	23 37 E.	At sea; Prince William Sound. Cook; Voyage, etc., 3 vols., 4°. London, 1784, vol. iii, p. 507. [To this I give weight ½ in the discussion—SCH.]
2 {	1787, May	26 00	Chalmer's Harbor, $\phi = 60° 17'$, $\lambda = 147° 27'$. Portlock; Voyage, etc., 4°, London, 1789.
	1787, May and July	26 30	Port Etches, Garden Cove, $\phi = 60° 20'.5$, $\lambda = 146° 46'$; reference as above; maps, pp. 215 and 226.
	1787	27 00	James Johnstone, Dalrymple's Charts. Cape Hinchinbrock in $\phi = 60° 18'$, $\lambda = 147° 0'$. [Not used.—SCH.]
3	1790	26 28	Nuchek; Constantine Redoubt. Sarycheff, old Russian chart without date or number, $\phi = 60° 18'$, $\lambda = 146° 32'$.
	1790, July 30	28 30	At sea, in Prince William Sound, $\phi = 60° 16'$, $\lambda = 146° 57'$; Billings. Sauer (M.), Account of a Geographical and Astronomical Expedition, 4°. London, 1802, p. 200. [Not used—SCH.]
4	1794, June	28 30	Port Chalmers, Vancouver; Voyage, etc., 3 vols., 4°. London, 1798, vol. 3, p. 188; $\phi = 60° 16'$, $\lambda = 146° 38'$; 30 sets, with four compasses ranging from 26° 50′ to 30° 09′.
	1810 (?)	28 07.5	Nuchek; old Russian chart No. xvii; Sarycheff, in $\phi = 60° 17'.5$, $\lambda = 147° 00'$. [Not used—SCH.]
5	1830	31 38	Nuchek; Constantine Redoubt. Chernoff, Russian hydrographic chart, 1378, published in 1847; in ϕ 60° 20′, $\lambda = 146° 32'.5$
6	1837, August 27	31 38	Port Etches, on beach near Phipp's Point. Sir Edward Belcher. Sabine, in Phil. Trans. Roy. Soc., 1843, part 2, and contributions, xiii, 1872; in $\phi = 60° 21'$ $\lambda = 146° 41'$.
7	1874, May 31	29 09.8 E.	Marcus Baker, U. S. Coast Survey (W. H. Dall, chief of party); Port Etches, on beach near Phipp's Point. Geographical position as in heading.

N. B.—For the communication of the above collection, excepting Nos. 6 and 7, I am indebted to Mr. M. Baker.

Collection of Magnetic Declinations, etc.—Continued.

ST. PAUL, KADIAK ISLAND, ALASKA.

$\phi = 57^\circ 48'.0$ $\lambda = 152^\circ 21'.3$ W. of Gr.

(Astronomical station of 1867.)

		°	′		
1 {	1778, May 21	23	42	E.	Cook; Voyage to the Pacific Ocean, 4°. London, 1784, vol. 2, pp. 507-8.
	1778, June 13	20	31		May 21. At sea, off Pye Islands, $\phi=59^\circ 30'.3$, $\lambda = 149^\circ 54'$ June 13. At sea, off SW. end of Kadiak, $\phi = 56^\circ 49'$, $\lambda = 154^\circ 20'$ Mean, $\phi = 58^\circ 10'$, $\lambda = 152^\circ 07'$ [Taking the mean value, we have for 1778.4 the declination $-22^\circ 06'$, to which I have given the weight ½ in the discussion.—SCH.] †
2	1790	25	30		Sarycheff; old Russian chart; no date.
3	1804, August 16	26	07		U. Lisiansky; Voyage, etc., London, 1814, p. 365.
4 {	1808	26	00		Russian naval officer; old Russian chart, sheet xvi. In $\phi = 57^\circ 47'.2$, $\lambda = 152^\circ 18'.3$
	1808	25	30		[The mean declination, or $-25^\circ 45'$ will be used.—SCH.] †
5	1818, July 19	26	30		Golovnin (V. M.); Voyage, etc., 4°. St. Petersburg, 1822, vol. 2, p. 59. At St. Paul Harbor; in front of governor's house, on hill, in $\phi = 57^\circ 47'.2$, $\lambda = 152^\circ 18'.3$ †
6	1834	28	38		Murasheff. At St. Paul's Harbor; Russian hydrographic chart, 1425. †
7	1839, July	26	43		Sir Edward Belcher; Phil. Trans. Roy. Soc., 1843, part 2. Near Cape Greville, in $\phi = 57^\circ 20'$, $\lambda = 152^\circ 51'$.
8	1845 (?)	27	00		Vasilieff, Tebenkoff's Atlas; xxiii. St. Paul's Harbor. †
9	1867, August 28, 29	26	05		A. T. Mosman, assistant Coast Survey. Harbor of St. Paul; at astronomical station on steep rocky bluff, about 1½ miles east of village, in $\phi = 57^\circ 48'.0$, $\lambda = 152^\circ 21'.3$
10	1874, June 7	25	22		M. Baker and W. H. Dall, U. S. Coast Survey.
11	1880, July 9	25	09	E.	M. Baker and W. H. Dall, U. S. Coast and Geodetic Survey; at Chagafka Cove, harbor of St. Paul.

N. B.—Results marked thus † were communicated by Mr. M. Baker, of the Coast and Geodetic Survey.

CAPTAIN'S HARBOR, UNALASHKA ISLAND, ALASKA.

$\phi = 53^\circ 52'.6$ $\lambda = 166^\circ 31'.5$ W. of Gr.

(Greek Church, Iliuliuk Village.)

		°	′		
	1778, October 12	19	59.2	E.	Capt. J. Cook; Voyage to the Pacific Ocean, London, 1784. Position on shore of Samganuda Harbor, $\phi = 53^\circ 55'$, $\lambda = 166^\circ 30'$ W. [Not used.—SCH.]
	1789	19	30		John Henry Cox. Dalrymple's Charts; Muscle Cove, $\phi = 53^\circ 50'$ [Not used.—SCH.]
1	1790, June 4–13	19	35		Commodore J. Billings; M. Sauer, an account of a geographical and astronomical expedition to the northern parts of Russia, London, 1802. On shore of Beaver Bay, in $\phi = 53^\circ 56'$, $\lambda = 165^\circ 40'$.
2	1792	19	00		Sarycheff, old Russian chart; no date, year doubtful. At Iliuliuk, $\phi = 53^\circ 57'$, $\lambda = 166^\circ 32'$. Communicated by Dr. W. H. Dall, acting assistant Coast Survey, November, 1873.
3	1817, June	19	24		Otto v. Kotzebue; Voyage of Discovery into the South Sea, London, 1821. Iliuliuk Village, in $\phi = 53^\circ 52'.4$, $\lambda = 166^\circ 31'.9$ Communications by Dr. Dall and Mr. M. Baker, of the United States Coast Survey. [In the edition of this paper of 1874 *the date* 1806 *was in error.*]
4	1827, August 11	19	50		Capt. F. P. Lütke; Lenz, in Mem. St. Pet. Acad. Sc., vi serie Math. et Phys. Sc., vol. 1, 1838. In $\phi = 53^\circ 54'$, $\lambda = 165^\circ 30'$.
	1829.0	19	54		Capt. F. P. Lütke; Gen. Sir E. Sabine, in Phil. Trans. Roy. Soc., London, 1872, vol. 162. Supposed to be derived from above observation of 1827 and reduced to 1829. [Not used.—SCH.]
5	1831	19	30		Vasilieff? At sea, north of Akutan; Reuss. Hydr. Ch. No. 1379, 1847; $\phi = 54^\circ.4$, $\lambda = 166^\circ.0$
	1848	19	30.5		Is supposed to be identical with preceding observation; hence omitted in this edition.
6	1849	20	00		Tebenkoff's Atlas, chart No. xxv; near church of Iliuliuk, in $\phi = 53^\circ 52'$, $\lambda = 166^\circ 25'$. Observation doubtful.
7	1867, September 8, 9	19	47.4		A. T. Mosman, assistant United States Coast Survey; party in charge of Assistant G. Davidson. At Captain's Harbor (on shore), at Spithead, in $\phi = 53^\circ 53'.9$, $\lambda = 166^\circ 30'.4$ MS. in Coast Survey archives.
8	1870	19	45		Kadin; MS. chart of Iliuliuk and Captain's Harbor. Communicated by Dr. W. H. Dall.
	1871, November 11	18	36		Dr. W. H. Dall, observer; Amaknak Island, opposite village. [Not used.—SCH.]
9 {	1873, May 26, 27	19	07.2		W. H. Dall, observer; near church of Iliuliuk, in $\phi = 53^\circ 52'.6$, $\lambda = 166^\circ 31'.6$
	1873, September 17	18	59.7		M. Baker, observer; Amaknak Island, off village, in $\phi = 53^\circ 52'.9$, $\lambda = 166^\circ 31'.7$ [Mean used, $-19^\circ.06$—SCH.]
10	1874, September 13	18	42.8		M. Baker, observer; MS. of observations for Nos. 10 and 11 in Coast Survey archives.
11	1880, July 28, 29	18	38	E.	M. Baker and W. H. Dall, United States Coast and Geodetic Survey, Iliuliuk Harbor. Position the same as in 1873.

N. B.—For the collection and communication of observations Nos. 0, 1, 4, and 5, I am indebted to Mr. Marcus Baker, of the Computing Division, Coast and Geodetic Survey.

Collection of Magnetic Declinations, etc.—Continued

PETROPAVLOVSK, KAMTCHATKA.

$\phi = 53° 01'$ $\lambda = 201° 17'$ W. of Gr.

		° ′	
1	1779, June	6 18.7 E.	Capt. J. King; A Voyage to the Pacific Ocean, London, 1784. West side of village, $\phi = 53° 00'.6$, $\lambda = -158° 43'.3$
2	1792	6 00	G. Sarycheff; F. P. Lütke's Voyage round the World, St. Petersburg, 1835.
3	1804, September	5 20	A. J. von Krusenstern; Voyage round the World, London, 1813. On the spot on which the village stands, in $\phi = 53° 00'.2$, $\lambda = -158° 47'.7$
	1804, September	5 39	Observer and references as above; on Avatcha Bay. [Used mean of the two values, $-5°.49$]
	1809, June 23, July 23	7 21	Capt. Hagemeister, mean by two compasses. A. G. Erman; Reise um die Erde, Berlin, 1835, vol. 2. Communicated by Mr. M. Baker. [Not used.—SCH.]
	1825.5	4 13	Gen. Sir. E. Sabine's Conts. to Terr. Mag., No. xiii, in Phil. Trans. Roy. Soc., 1872; $\phi = 53° 00'$, $\lambda = 201° 20'$ W. [This is supposed to refer to Capt. Beechey's observations of 1827. Not used.—SCH.]
4	1827, July	4 13.3	Capt. F. W. Beechey; Narrative of a Voyage to the Pacific, 1825 to 1828; London, 1831; in $\phi = 53° 01'$, $\lambda = -158° 43'.5$ Mean of 9 determinations.
	1827, September 30	3 43	Capt. F. P. Lütke; Lenz, in Mem. St. Peters. Acad. Sc., vi, vol. 1, 1838. In $\phi = 53° 01'$, $\lambda = -158° 44'$.
	1827, September 30	4 05.8	A. Erman; Reise um die Erde, Berlin, 1835. In $\phi = 53° 00'.5$, $\lambda = -156° 19'.8$ from Paris. [Mean of 3 determinations used, giving the middle one ½ weight; hence for 1827.6, $D = -4°.07$—SCH.]
	1829.5	4 04	Gen. Sir E. Sabine's Conts. to Terr. Mag., in Phil. Trans. Roy. Soc., 1872. [This is supposed to refer to Erman's value of 1827. Not used.—SCH.]
	1837, September 4	3 27	Du Petit Thouars, Voyage autour du Monde, Paris, 1843. In front of Auchard's house, in $\phi = 53° 01'$, $\lambda = -156° 23'$ from Paris.
6	1849.5	2 37	Capt. H. Kellet; Gen. Sir E. Sabine in Phil. Trans. Roy. Soc., London, 1872, vol. 162.
7	1854, July	3 40	Frigate Aurora; Compte-Rendu Annuel de l'Observ. Phys. Cent. de Russie; année 1854; St. Pétersb., 1855. In $\phi = 53° 00'$, $\lambda = -158° 43'.5$ [Apparently anomalous; weight assigned ½.—SCH.]
	1856, October	3 24	Admiralty chart No. 2460. Position of Petropavlovsk in Encyc. Brit., 7th edition, $\phi = 53° 01'$, $\lambda = 201° 17'$ W. of Gr. [Probably computed value; not used.—SCH.]
8	1866	1 25.1	K. S. Staritzky; Onazevich's collection of observations made during hydr. explor. in the Pacific, 1874-'77; St. Petersb., 1878.
9	1876, June 11, 13, September 15	1 09 E.	M. L. Onazevich. Reference as above.

N. B.—This important Asiatic station is included in the discussion on account of its proximity to the Western Aleutian or Rat Islands. For information Nos. 3, part of 4, 5, 7, and 9, I am indebted to Mr. Marcus Baker, of the Computing Division, Coast and Geodetic Survey Office.

COLLECTION OF RESULTS AT SECONDARY STATIONS.

The following collection of declinations comprises all stations at which the results of observation could not be as satisfactorily discussed as for the preceding stations. The defect arising either from actual paucity of available material or from shortness of elapsed time between the extreme epochs covered by the observations. The declinations at the greater number of these stations, however, have been discussed by application of an exponential function in the place of the former circular function. For a few stations a collection of data only is given, but they will be worked up whenever they become sufficiently complete to warrant the attempt.

ST. JOHN'S, NEWFOUNDLAND.

$\phi = 47° 34'.4$ $\lambda = 52° 41'.9$ W. of Gr.

(Government House.)

		° ′	
1	1844, October	29 36 W.	Capt. Bayfield, R. N., in Phil. Trans. Roy. Soc., 1849, p. 211.
2	1857, July	31 21	Capt. Dayman, R. N. Account of deep-sea soundings in the North Atlantic Ocean, 1858, p. 61.
3	1862, September 11	31 20	Capt. Orlebar, R. N.
4	1863, September 22	31 18	Capt. Orlebar, R. N.
5	1864, June 3	31 00	Capt. Orlebar, R. N.
6	1866, April to October	30 55	Near Government House.
7	1881, September 26, 27, 28	30 37.3 W.	S. W. Very, Lieut. U. S. N., acting assistant, U. S. Coast and Geodetic Survey. N. W. corner of grounds surrounding the Government House.

N. B.—The above declinations were communicated in 1866 and 1867, by Staff-Commander F. J. Evans, hydrographer, British Admiralty. [According to Halley's chart the declination in 1700 was nearly 15° W.—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

CHARLOTTE TOWN, PRINCE EDWARD ISLAND, CANADA.

$\phi = 46° 14'$ $\lambda = 63° 27'$ W. of G.

		° ′		
1	1842, June	21 03	W.	Captain Bayfield, R. N.; letter of Staff Commander F. J. Evans, January 5, 1866; Phil. Trans. Roy. Soc., 1849, p. 211.
2	1857, May	23 02		Capt. Orlebar, R. N. Reference as above.
3	1858, May 18	22 54		Capt. Orlebar, R. N. Reference as above.
4	1859, May 20	22 51		Capt. Orlebar, R. N. Reference as above.
5	1860, May 17	22 50		Capt. Orlebar, R. N. Reference as above.
6	1861, May 14	22 45		Capt. Orlebar, R. N. Reference as above.
7	1862, May 27	23 19	W.	Capt. Orlebar, R. N. Reference as above.

HANOVER, N. H.

$\phi = 43° 42'.3$ $\lambda = 72° 17'.1$ W. of Gr.

(Dartmouth College Observatory.)

		° ′		
1	1765	7 00	W.	President Wheelock; in $\phi = 43° 41'$, $\lambda = 72° 10'$; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838.
2	1810	4 15		
3	1839	9 15		Prof. Young; in $\phi = 43° 42'$, $\lambda = 72° 10'$; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxix, 1840.
4	1873, October 4, 6, 9, 10, 11	10 49.6		Dr. T. C. Hilgard, observer for United States Coast Survey; MS. in Coast Survey archives.
5	1879, October 6	10 50.5		J. B. Baylor, United States Coast and Geodetic Survey. Station of Oct. 6 same as that of 1873, a little north of Observatory. Station of Oct. 7, ¾ mile west of Observatory hill, in $\phi = 43° 42'.3$, $\lambda = 72° 18'.0$
	1879, October 7	11 38.4	W.	

CHESTERFIELD, N. H.*

$\phi = 42° 53'$ $\lambda = 72° 23'$ W. of Gr.

	° ′		
1812	6 26	W.	Nathan Wilde.
1813	6 25		
1814	6 17		
1815	6 07		
1816	6 03		
1817	6 02		
1818	6 00		
1819	6 03		
1820	6 00		
1821	6 07		
1822	6 12		
1823	6 30		
1824	6 40		
1825	6 35		
1826	6 35		
1827	6 45		
1828	6 52		
1829	7 00		
1830	7 06		
1831	7 10		
1832	7 15		
1833	7 30		
1834	7 35		
1835	7 40		
1836	7 45		
1837	8 05	W.	A. C. Twining.

*From Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; position assigned, $\phi = 42° 53'$, $\lambda = 72° 20'$.

Collection of Magnetic Declinations, etc.—Continued.

TYRONE, PA.

$\phi = 40° 40'$ $\lambda = 78° 15'.5$ W. of Gr.

		° ′		
1	1871, September 25	3 06	W.	Observer, W. G. Waring; results communicated by him in a letter dated from Tyrone, Pa., April 14, 1879.
	1871, September 27	3 12		[Correcting the results for diurnal variations and contracting to yearly means, I find the following results.—SCH.]
2	1873, April 3	3 24		
	1873, May 10; noon	3 22		
	1873, June 18; 10 a.m	3 19		
3	1874, May 29	3 20		°
4	1875, June 2	3 26		1871.65 +3.15
5	1878, November 6; 10½ a.m	3 45		1873.36 3.35
	1878, November 14; 9 a.m.	3 39		1874.41 3.33
	1878, November 14; noon	3 43		1875.42 3.43
	1878, December 13; 4 p.m	3 43.5		1878.88 3.70
6	1879, March 18; 1 p.m	3 52	W.	1879.21 3.80

PITTSBURGH, PA.

$\phi = 40° 27'.6$ $\lambda = 80° 00'.8$ W. of Gr.

(Allegheny Observatory, Allegheny.)

		° ′		
1	1840, August 10	0 08	W.	Dr. A. D. Bache, at Homewood, in $\phi = 40° 28'$, $\lambda = 79° 59'.5$; Coast Survey Report for 1862, App. No. 19.
2	1845, May 3	0 33.1		Dr. J. Locke, in $\phi = 40° 26'$, $\lambda = 79° 58'$; Coast Survey Report for 1855, p. 304.
3	1878, September 5	2 21.6	W.	Dr. T. E. Thorpe, Proc. Roy. Soc., No. 200, 1880, at Allegheny, grounds of observatory, latitude and longitude as above.

CHICAGO, ILL.

$\phi = 41° 50'.0$ $\lambda = 87° 36'.7$ W. of Gr.

(Observatory, Dearborn University.)

		° ′		
1	1823	6 12	E.	Major Long's expedition; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838, in $\phi = 42° 00'$, $\lambda = 87° 40'$.
2	1857, July 23	5 46.1		Lieut. Col. J. D. Graham, Pub. Doc. 35th Cong., 1st Sess., No. 42, 1858, in $\phi = 41° 54'$, $\lambda = 87° 38'$.
3	1878, September 2	4 33.1	E.	Dr. T. E. Thorpe, Proc. Roy. Soc., No. 200, 1880; grounds of Chicago University; position as in heading.

GRAND HAVEN, MICH.

$\phi = 43° 05'.2$ $\lambda = 86° 12'.6$ W. of Gr.

1	1825	3¾° to 6°	E.	L. Lyon; at Grand River, $\phi = 42° 55'$, $\lambda = 86° 10'$. Prof. E. Loomis, Sill. Jour., vol. xxxix, 1840. [Giving double weight to second value, we may use—5°. 25—SCH.]
		° ′		
2	1837	4 30	E.	Geological Report; reference as above. $\phi = 42° 55'$, $\lambda = 86° 10'$.
		6 15		Geological Report; reference as above. $\phi = 43° 19'$, $\lambda = 85° 59'$. [Weighted mean, first value double weight, —5°.08—SCH.]
3	1859, August 18	4 24.2		Lieut. W. P. Smith, Survey N. and N. W. Lakes; report by Capt. G. G. Meade, Detroit, 1859; $\phi = 43° 05'.2$, $\lambda = 86° 12'.6$
4	1865	4 15		Survey of N. and N. W. Lakes; MS. by Colonel Raynolds, Dec. 1865; $\phi = 43° 04'$, $\lambda = 86° 13'$.
5	1873, August 28, 29	3 28.2		Capt. A. N. Lee; Survey of N. and N. W. Lakes; MS., 1873; see also report of Chief of Engineers, 1874.
6	1880, July 20, 21	2 25.7	E.	J. B. Baylor, U. S. Coast and Geodetic Survey; in grounds of county court-house; $\phi = 43° 04.7$, $\lambda = 86° 12'.6$

Collection of Magnetic Declinations, etc.—Continued.

MILWAUKEE, WIS.

$\phi = 43° 03'$ $\lambda = 87° 56'$ W. of Gr.

		° ′	
1	1859, August 20	6 20.1 E.	Lieut. W. P. Smith, U. S. Survey of N. and N. W. Lakes; communicated by Capt. G. G. Meade, Detroit, 1859; in $\phi = 43° 02'.8$, $\lambda = 87° 55'.1$
2	1873, August 22	6 22.4	Capt. A. N. Lee, U. S. Engineers, Survey of N. and N. W. Lakes; Gen. C. B. Comstock, in charge; MS., 1873, position as above.
3	1878, May	6 43 E.	Maj. D. C. Houston, U. S. Engineers; Report of Chief of Engineers, 1878, part II, p. 1166, map.

MADISON, WIS.

$\phi = 43° 04'.6$ $\lambda = 89° 24'.2$ W. of Gr.

(University of Wisconsin.)

		° ′		
1	1839, November 2	7 30 E.	Dr. J. Locke, in survey of "Mineral Lands," Ex. Doc. 1839-'40, vol. vi, No. 239. In $\phi = 43° 03'$, $\lambda = 89° 11'$.	
2	1841, September	7 30	Prof. E. Loomis; Phil. Trans. Roy. Soc., 1872. In $\phi = 43° 03'$, $\lambda = 89° 06'$. [Dr. Locke and Prof. Loomis observed S. E. of the statehouse (or capitol); the position of the capitol is in $\phi = 43° 04'.5$, $\lambda = 89° 23'.0$ U. S. Coast and Geodetic Survey.—Sch.]	
	1876, October 10, 11, 12, 13, 14	6 59.7	F. E. Hilgard, observer for U. S. Coast Survey. [Not used.—Sch.]	Station near and south of University central building, in $\phi = 43° 04'.5$, $\lambda = 89° 24'.2$ [Was found affected by erection of water-tank and vertical pipes, new station established in 1878 on the University farm, about 1 mile west of it.]
	1877, August 30; September 1 to 21.	6 44.9	A. Braid, U. S. Coast Survey. [Not used.—Sch.]	
3	1878, August 29, 30	6 34.0	Dr. Gustavus Hinrichs, in connection with magnetic survey of Iowa.	
	1878, September 8, 9, 10, 11, 12, 13	6 31.8	W. Suess, observer for U. S. Coast and Geodetic Survey.	
	1878, November 22, 23, 25	6 22.9	J. B. Baylor, U. S. Coast and Geodetic Survey. Weight assigned, ½.	
4	1879, September 22 to October 11.	6 26.8	D. Mason, observer for U. S. Coast and Geodetic Survey.	
5	1880, September 15, 16, 17, 18, 21, 22.	6 20.9	D. Mason, observer for U. S. Coast and Geodetic Survey.	
3*	1878, November 13, 14, 15	6 31.7	J. B. Baylor	Station on farm, in $\phi = 43° 04'.5$, $\lambda = 89° 25'.2$ — Mean 1878.8 — 6° 31′.3 E. — [Means adopted.—Sch.]
4*	1879, October 6, 7, 8, 9	6 30.9	D. Mason	Mean 1879.7 — 6 28.8
5*	1880, September 23, 24, 25, 27, 28	6 22.9	D. Mason	Mean 1880.7 — 6 21.9
6*	1881, December 16, 17, 18, 19	6 21.0 E.	W. Suess	Mean 1881.9 — 6 19.8 E.

*Station on University farm.

MICHIPICOTON, ONTARIO, CANADA.

$\phi = 47° 56'.0$ $\lambda = 84° 50'.6$ W. of Gr.

(Garden, Hudson Bay Company's grounds.)

		° ′	
1	1824	4 33 E.	Capt. Bayfield, R. N. } Sir E. Sabine, in Phil. Trans. Roy. Soc., 1872, cont'n xiii.
2	1844	3 49 E.	Capt. Lefroy, R. E. } Fort Michipicoton is placed in $\phi = 47° 56'$, $\lambda = 85° 05'$.
3	1880, July 21 and September 9	1 20.5 W.	S. W. Very, Lieut. U. S. N., acting assistant U. S. Coast and Geodetic Survey. Position as in heading.

Collection of Magnetic Declinations, etc.—Continued.

DULUTH, MINN. AND SUPERIOR CITY, WIS.

$\phi = 46° 45'.5$ $\phi = 46° 40'$
$\lambda = 92° 04'.5$ $\lambda = 92° 04'$

		° ′	
1	1824.5	12 30 E.	Capt. Bayfield, at River Saint Louis, near Fond du Lac, in $\phi = 46° 43'$, $\lambda = 92° 10'$. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1872, cont'n xiii.
2	1859, July	9 25.2	Lieut. W. P. Smith, U. S. Survey of N. and N. W. Lakes; Capt. G. G. Meade, Detroit, 1859. At Minnesota Point, in $\phi = 46° 46'$, $\lambda = 92° 14'$.
3	1861	10 12	U. S. Survey of N. and N. W. Lakes.
4	1870, September 20	10 30	Gen. C. B. Comstock; U. S. Lake Survey. MS. of May 7, 1875. At Superior City, in $\phi = 46° 43'$, $\lambda = 92° 04'$.
5	1871, June 25	10 40	Gen. C. B. Comstock; U. S. Lake Survey. Reference as above. At Duluth, north base, in $\phi = 46° 45'.4$, $\lambda = 92° 04'.5$
6	1873, August 13, 15	11 52.3	Capt. A. N. Lee, U. S. Engineers; Survey of N. and N. W. Lakes. MS. communicated by General Comstock, 1873. In the Report of Chief of Engineers for 1874. Decl'n, Aug. 13, 11° 52'.3 E. At Duluth, in $\phi = 46° 45'.5$, $\lambda = 92° 04'.5$
7	1880, August 21, 23	9 45.4 E.	J. B. Baylor, U. S. Coast and Geodetic Survey. At Superior City, in $\phi = 46° 40'$, $\lambda = 92° 04'$.

CAPE HENLOPEN, DEL.

$\phi = 38° 46'.7$ $\lambda = 75° 05'.0$ W. of Gr.

(Light-house.)

		° ′	
1	1795	0 55 W.	Aurora. At Lewiston, in $\phi = 38° 44'$, $\lambda = 75° 00'$. Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1841, May	4 42	Barnett; Phil. Trans. Roy. Soc., 1841. [Probably of no value.—Sch.]
3	1843, October and November	2 26.0	S. P. Lee, U. S. N., acting assistant U. S. Coast Survey. Near light-house.
4	1846, July 1	2 45.0	Dr. John Locke, acting assistant U. S. Coast Survey. At Lewis Landing.
5	1856, August 27	3 03.9 W.	C. A. Schott, assistant Coast Survey. Near and southwest of light-house, in $\phi = 38° 46'.5$, $\lambda = 75° 05'.3$

WILLIAMSBURG, JAMES CITY COUNTY, VA.

$\phi = 37° 16'.2$ $\lambda = 76° 42'.4$ W. of Gr.

		° ′	
1	1694	5 W.	Bishop Madison, president of William and Mary's College, in $\phi = 37° 15'$, $\lambda = 76° 35'$; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1780	0 50 W.	
3	1809	0 33 E.	
4	1874, December 4, 5, 6, 8, 9	2 12 W.	J. B. Baylor, aid United States Coast Survey; $\phi = 37° 16'.3$, $\lambda = 76° 42'.7$; MS. in Coast Survey archives.

NEW BERNE, N. C.

$\phi = 35° 06'$ $\lambda = 77° 02'$ W. of Gr.

		° ′	
1	1796	2 40 E.	Jonath. Price; from Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; position assigned, $\phi = 35° 20'$, $\lambda = 77° 05'$.
2	1806	2 00	
3	1809	1 45 E.	
4	1874, December 21, 23, 24	1 20.4 W.	J. B. Baylor, aid United States Coast Survey; $\phi = 35° 07'.4$, $\lambda = 77° 03'.3$; MS. in Coast Survey archives.

MILLEDGEVILLE, GA.

$\phi = 33° 04'.2$ $\lambda = 83° 10'$ W. of Gr.

		° ′	
1	1805	5 30 E.	J. Bethune, Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1835	4 40	J. Bethune. Reference as above.
3	1838	5 51	Geological survey of Georgia. Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840. The position assigned is $\phi = 33° 07'$, $\lambda = 83° 20'$.
4	1875, June 18	3 03.5 E.	J. M. Poole, Bache-Fund observer Nat'l Acad. of Sc. [On June 15, 1875, he found the value 4° 14'.1—perhaps a misreading of 1°. A new determination is needed to decide between the two values.—Sch.]

Collection of Magnetic Declinations, etc.—Continued.

BERMUDA ISLANDS.

$\phi = 32° 23'$ $\lambda = 64° 42'$ W. of Gr.

(Signal station, St. George's Town.)

		° ′		
1	1831	6 59	W.	Austin and Foster; Sir Edw. Sabine in Phil. Trans. Roy. Soc., 1874, Conts., xiv. In $\phi = 32° 23'$, $\lambda = 64° 47'$.
2	1837	6 40		Milne; reference as above.
3	1845, October	7 01		Captain Barnett, Royal Engineers; Bermuda Royal Gazette. At signal station, $\phi = 32° 32'$, $\lambda = 64° 40'$.
4	1846	6 53		Captain Barnett, Royal Engineers; Sir Edw. Sabine, Phil. Trans. Roy. Soc., 1874, Conts., xiv. Position $\phi = 32° 23'$, $\lambda = 64° 47'$.
5	1876	7 45	W.	Admiralty Chart 360, issued February, 1877. Annual increase of declination about 3′.

RIO JANEIRO, BRAZIL.**

$\phi = -22° 54'.8$ $\lambda = 43° 09'.5$ *W. of Gr.*†

(Fort Villegagnon flagstaff.)

		° ′		
1	1768	7 34	E.	Cook } Voyages of the Adventure and Beagle, 1826-'36, vol. 1, Capt. P. P. King, London, 1839, p. 523. Discussion by Major Sabine.
2	1787	6 12		Hunter }
3	1820	2 54		Freycinet }
4	1821	3 21		Rumker }
5	1830, May 23, 25, 26, June 2, 5, 13.	2 08.4		Erman (A. G.); Reise um die Erde, etc., Berlin, 1835. In $\phi = -22° 53'.9$, $\lambda = 43° 05'.2$
6	1836	2 00	E.	Fitz Roy. Voyages of the Adventure and Beagle, 1826-'36.
7	1857	1 20	W.	Capts. E. O. Stanley and G. H. Richards, and Lieut. Bullock, R. N.; Admiralty Chart No. 541. Fort Villegagnon $\phi = -22° 54'.7$, $\lambda = 43° 09'.0$ W.
8	1866, January 8	2 41.8		W. Harkness, Prof. U. S. N.; position near north face of Fort Caraguata, in $\phi = -22° 54'.1$, $\lambda = 43° 06'.5$ W. of Gr. Smithsonian Contributions to Knowledge, No. 239, Washington, 1873, p. 61.
9	1876.5	4 26	W.	Samuel W. Very, Lieutenant U. S. N. From numerous observations at various times and different places. MS. communication of December 13, 1879.

** At this place the secular change is progressing perhaps at the most rapid rate known within the tropics and close to the magnetic equator.
† Longitude from telegraphic determinations of longitudes, Lieut. Comdrs. Green and Davis, U. S. N., 1878-'79. Washington, D. C., 1880.

NASHVILLE, TENN.

$\phi = 36° 10'.0$ $\lambda = 86° 47'.0$ W. of Gr.

(State House.)

		° ′		
1	1829	6 50	E.	Prof. Hamilton; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. In $\phi = 36° 10'$, $\lambda = 86° 49'$.
2	1835	7 07		Prof. Hamilton. Reference as above.
3	1877, December 5, 6, 7	5 14.9	E.	A. Braid, U. S. Coast Survey. Grounds of Vanderbilt University, in $\phi = 36° 09'.7$, $\lambda = 86° 47'.6$

NATCHEZ, MISS.

$\phi = 31° 33'.5$ $\lambda = 91° 24'.0$ W. of Gr.

(Coast and Geodetic Survey, astronomical station.)

		° ′		
1	1802	9 0	E.	Dunbar; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. In $\phi = 31° 34'$, $\lambda = 91° 25'$.
2	1872, April 21, 22	7 14.8		Dr. Th. C. Hilgard, Bache-Fund observer; Nat. Acad. of Sc. In $\phi = 31° 34'$, $\lambda = 91° 24'$.
3	1878-'79	7 23	E.	W. H. Dennis, assistant U. S. Coast and Geodetic Survey. In $\phi = 31° 33'.5$, $\lambda = 91° 24'.1$ Marked on triangulation sketch.

Collection of Magnetic Declinations, etc.—Continued.

SAN ANTONIO, TEXAS.

$\phi = 29° 25'.4$ $\lambda = 98° 29'.3$ W. of Gr.

(Arsenal grounds.)

		° ′	
1	1825	10 30 E.	Land Office record at San Antonio. Communicated by Mr. J. B. Baylor.
2	1836	9 45	
3	1874	9 30	
4	1878, June 10, 11, 12	9 22.3 E.	J. B. Baylor, U. S. Coast and Geodetic Survey; arsenal grounds, position as given above.

OMAHA, NEBRASKA AND COUNCIL BLUFFS, IOWA.

$\phi = 41° 15'.7$ $\lambda = 95° 56'.5$ W. of Gr.

(Astronomical Station, grounds of High School.)

		° ′	
1	1819, September 22	12 58.8 E.	Major St. H. Long, U. S. A., Expedition to the Rocky Mountains, Phila., 1823 (two volumes). At Engineers' Cantonment, $\phi = 41° 25'$. $\lambda = 96° 00'$.
2	1869, January 25, 26, 27; February 12, 13.	10 42.6	E. Goodfellow, assistant Coast Survey; at astronomical station.
3	1872, October 31	10 44.2	Dr. T. C. Hilgard; Bache-Fund Observer to National Academy; station as above.
4	1877, October 13, 15, 16, 17, 18	10 22.0	A. Braid, U. S. Coast Survey, station of 1869.
5	1878, August 30	10 39.7	Dr. T. E. Thorpe; Proc. Roy. Soc. No. 200, 1880. At Council Bluffs, near railroad depot. $\phi = 41° 15'.3$, $\lambda = 95° 52'.4$
6	1880, October 15, 17	10 06.2 E.	J. B. Baylor, U. S. Coast and Geodetic Survey. Station on High School grounds as in 1869, 1872 and 1877.

DENVER, COL.

$\phi = 39° 45'.3$ $\lambda = 104° 59'.5$ W. of Gr.

(Coast Survey Astronomical Station, west of School-house.

		° ′	
1	1866, July	15 0 E.	John Prince, surveyor-general of Colorado; letter of July 27, 1866. In $\phi = 39° 45'$, $\lambda = 105° 00'$.
2	1872, October 13, 14, 19.	14 44.7	Dr. Th. C. Hilgard; Bache-Fund observer, National Academy of Science.
3	1873, August 14	14 42.8	E. Smith, assistant Coast Survey. At astronomical station in $\phi = 39° 45'.3$, $\lambda = 104° 59'.5$
4	1878, August 8	14 43.4	Dr. T. E. Thorpe; Proc. Roy. Soc. No. 200, 1880. In Mrs. Craig's garden, $\phi = 30° 45'.3$, $\lambda = 104° 59'.6$
	1878, September 3, 4, 5	14 40.2 E.	J. B. Baylor, U. S. Coast and Geodetic Survey. Corner of 17th street and Broadway. Position as in heading. [Mean of observations of 1878, 14° 41'.8]

SALT LAKE CITY, UTAH.

$\lambda = 40° 46'.1$ $\lambda = 111° 53'.8$ W. of Gr.

(Astronomical Station, Temple Square.)

		° ′	
1	1850	15 34 E.	Major W. H. Emory, U. S. A., Amer. Acad. of Science, vol. vi, new series, 1856; in $\phi = 40° 46'$, $\lambda = 112° 08'$.
2	1866, August	16 30	Jesse W. Fox; Letter from surveyor general's office dated August 29, 1866. $\phi = 40° 46'$, $\lambda = 111° 54'$.
3	1869, May 6 to 15	16 36.4	G. W. Dean, assistant Coast Survey; Temple Square near astronomical station.
4	1872	17 01	Report of Chief of Engineers, 1879, part iii, p. 2099. At Camp Douglass, near astronomical monument, in $\phi = 40° 45'.8$, $\lambda = 111° 50'.2$
5	1878, August 15	16 48.1	Dr. T. E. Thorpe; Proc. Roy. Soc. No. 200, 1880. East of the President's house, in $\phi = 40° 46'.1$, $\lambda = 111° 53'.7$
	1878, October 26, 28, 29	16 44.2	J. B. Baylor, U. S. Coast and Geodetic Survey, near Fourth street south and Second street east of Temple. [Mean of the two determinations of 1878,—6° 46'.2]
6	1881, May 12, 13, 14	16 28.4 E	W. Eimbeck, assistant Coast and Geodetic Survey; about 25 metres S. E. of astronomical station on Temple square.

Collection of Magnetic Declinations, etc.—Continued.

CAPE MENDOCINO, CAL.

$\phi = 40° 26'.3$ $\lambda = 124° 24'.2$ W. of Gr.

(Cape Mendocino light-house.)

		°	′		
1	1693	2		E.	Carreri; C. Hansteen's Magnetismus der Erde, 1819; in $\phi = 40° 29'$, $\lambda = 124° 29'$. [Declination probably much in error.—SCH.]*
2	1786, September 7, 8	14	54		La Pérouse (J. F. G. de); Voyage, etc. Paris, 1797, vol. iii, pp, 302, 390. On board the Boussole. Average $\phi = 40° 21'$, $\lambda = 124° 36'$; declination 14° 59′. On board the Astrolabe, about the same position; declination 14° 48′. Communicated by Mr. M. Baker.
	1792, April 18	16	00		Capt. G. Vancouver; near the cape, about ten leagues from it; it bore N. 36° W. [This would put him in about $\phi = 39° 58'$, $\lambda = 124° 12'$—SCH.] Vancouver's Voyage of Discovery, etc., 1790–95, London, 1798, vol. 1, p. 197.
3	1792, April 19	15	00		Same authority, vol. 1, p. 198; on board ship, in $\phi = 40° 03'$, $\lambda = 124° 09'$; Cape Mendocino bore N. 2° W. four leagues from shore.
	1792, April 22	16	00		Same authority, vol. 1, p. 200; in $\phi = 40° 32'$, $\lambda = 124° 32'$.
4	1794, October 3	14	00	E.	Same authority, vol. iii, p. 321. In $\phi = 40° 42'$, $\lambda = 124° 30'$.

* The latitude given would indicate that this navigator refers to False Cape Mendocino (now called Cape Fortunas), in $\phi = 40° 30'.5$ $\lambda = 124° 22'.8$—SCH.

WALLULA AND OLD FORT WALLA WALLA, WASHINGTON TERRITORY.

$\phi = 46° 05'$ $\lambda = 118° 55'$ W. of Gr.

		°	′		
1	1853	19	40	E.	Gov. I. I. Stevens; North Pacific Railroad Explorations. Coast Survey report for 1856, p. 223. At old Fort Walla Walla, in $\phi = 46° 04'$, $\lambda = 118° 48'$.
	1860	20	30		S. Garfielde, surveyor-general of Washington Territory. MS. communication of August 24, 1866. In town [Walla Walla or near Fort Walla Walla, in $\phi = 46° 03'$, $\lambda = 118° 20'$. Not used.—SCH.]
	1860	20	00		Capt. J. Mullan, U. S. A. J. B. Stone, "Mag. Var." New York, 1878. In $\phi = 46° 03'$, $\lambda = 118° 24'$ In town [Walla Walla or new fort.—SCH.].
2	1861	20	30		S. Garfielde; reference as above. At Wallula or old Fort Walla Walla, in $\phi = 46° 05'$, $\lambda = 118° 55'$—[SCH.]
	1881, September 24, 25, 26	22	04.4		J. S. Lawson, assistant Coast and Geodetic Survey. Town of Walla Walla, in $\phi = 46° 03'.9$, $\lambda = 118° 20'.5$ [Apparently some doubt about correctness of result.—SCH.].
3	1881, Sept. 29, 30; Oct. 1, 2	19	55.7	E.	J. S. Lawson, assistant Coast and Geodetic Survey. At Wallula, near and north of old fort, in $\phi = 46° 07'$, $\lambda = 118° 55'$ [Result in discord with preceding one.—SCH.]

FORT VANCOUVER, WASHINGTON TERRITORY.

$\phi = 45° 40'$ $\lambda = 122° 38'$ W. of Gr.

		°	′		
1	1839	19	22	E.	Sir Edw. Belcher. Phil. Trans. Roy. Soc., 1841, in $\phi = 45° 37'$, $\lambda = 122° 36'$
2	1859	21	30		S. Garfielde, surveyor-general Washington Territory; MS. communication of August 24, 1866. In $\phi = 45° 40'$, $\lambda = 122° 38'$.—[SCH.]
3	1860	20	05		Capt. R. W. Haig; English Boundary Commission. Phil. Trans. Roy. Soc., vol. 154, part II, 1864. In $\phi = 45° 38'$, $\lambda = 122° 28'$.
4	1881, October 26, 27	20	53.3	E.	J. S. Lawson, assistant Coast and Geodetic Survey. South of old fort in $\lambda = 45° 37.5'$, $\lambda = 122° 39'$.

OLYMPIA, WASHINGTON TERRITORY.

$\phi = 47° 02'$ $\lambda = 122° 54'$ W. of Gr.

		°	′		
1	1853	21	15	E.	S. Garfielde, surveyor-general Washington Territory; MS. communication of August 24, 1866. In $\phi = 47° 03'$, $\lambda = 122° 54'$.—[SCH.]
2	1856.5	20	47		Sir Edw. Sabine. Phil. Trans. Roy. Soc., 1872; communication XIII. In $\phi = 47° 03$, $\lambda = 122° 55'$. [Value apparently too small, as shown by observations at Steilacoom.—SCH.]
3	1881, November 2, 3, 4	21	34.6	E.	J. S. Lawson, assistant Coast and Geodetic Survey. In $\phi = 47° 02'.3$, $\lambda = 122° 54'.0$

Collection of Magnetic Declinations, etc.—Continued.

SEATTLE, DUWAMISH BAY, WASHINGTON TERRITORY.

$\phi = 47° 36'.0$ $\lambda = 122° 20'.0$ W. of Gr.

(Astronomical station of the U. S. Coast Survey.)

		° '		
1	1855	21 25	E.	S. Garfielde, surveyor-general of Washington Territory. MS. communication of August 24, 1866. In $\phi = 47° 36'$, $\lambda = 122° 20'$. [SCH.]
2	1871, Sept. 27, 28, 29, 30; Oct. 2, 3.	22 35.4		S. R. Throckmorton, observer for U. S. Coast Survey. In $\phi = 47° 35'.9$, $\lambda = 122° 20'.0$ [Result uncertain; doubtful azimuth.—SCH.]
3	1881, Nov. 8, 9, 10, 11	22 02.5	E.	J. S. Lawson, assistant Coast and Geodetic Survey. Station near that of 1871; geographical position as above.

PORT TOWNSHEND, WASHINGTON TERRITORY.

$\phi = 48° 07'.0$ $\lambda = 122° 44'.9$ W. of Gr.

(Point Hudson.)

		° '		
	1792, May	21 30	E.	Vancouver; at Port Discovery, $\phi = 48° 02'$, $\lambda = 122° 38'$; Hansteen's Magnetismus der Erde, 1819. [Not used; about 3° too great.—SCH.]
1	1841	20 40		Chart by the U. S. Exploring Expedition, at Carr Point. $\phi = 48° 03'.3$, $\lambda = 122° 50'.8$
2	1856, August 17, 18, 19, 20	21 39.5		G. Davidson, assistant Coast Survey; at Point Hudson. $\phi = 48° 06'.9$, $\lambda = 122° 44'.9$
3	1857	21 54		S. Garfielde, surveyor-general of Washington Territory; at Admiralty Head, Whitbey Island. $\phi = 48° 09'$, $\lambda = 122° 41'$. Letter of August 24, 1866. [Reduction to Port Townshend + 8'—SCH.]
	1859	20 45		Reference as above. $\phi = 48° 07'$, $\lambda = 122° 45'$. [Not used.—SCH.]
4	1862	22 00		Reference as above. $\phi = 48° 01'$, $\lambda = 121° 51'$ at Mill.
5	1876, February	21 50		Capt. G. H. Burton, U. S. A.; report of Chief of Engineers, 1876, p. 3.
6	1881, November 16, 17, 18	21 26.9	E.	J. S. Lawson, assist. Coast and Geodetic Survey. Astronomical station of 1852 at Point Hudson, in $\phi = 48° 07'.0$, $\lambda = 122° 44'.9$

PORT CLARENCE, ALASKA.

$\phi = 65° 17'$ $\lambda = 166° 19'$ W. of Gr.

		° '		
1	1827.5	26 55	E.	Capt. Beechey; Sir Edw. Sabine, in Phil. Tran. Roy. Soc., communication XIII, 1872. Port Clarence and Grantley Bay, in $\phi = 65° 17'$, $\lambda = 166° 19'$.
2	1850.5	26 26		Capt. Kellett. Reference as above.
3	1854.5	26 00		Capt. Maguire. Reference as above.
4	1879, July	23 01		Aug. Wykander, Nordenskiöld, in the Vega. Communicated by Dr. Dall.
5	1880, September 8	22 45	E.	M. Baker and W. H. Dall, U. S. Coast and Geodetic Survey. Port Clarence, near Point Spencer, in $\phi = 65° 16'.1$, $\lambda = 166° 50'.6$

CHAMISSO ISLAND (KOTZEBUE SOUND), ALASKA.

$\phi = 66° 13'.3$ $\lambda = 161° 48'.7$ W. of Gr.

		° '		
1	1826, August	31 24.3	E.	Capt. Beechey; Beechey's Voyage, p. 740. } Communicated by Mr. M. Baker.
1	1826.5	31 10		Brt. Admiralty Chart, No. 593 } Communicated by Mr. M. Baker.
1	1826.5	28 53		Capt. Beechey. Phil. Tran. Roy. Soc., 1872; Sir E. Sabine, continuation XIII.
2	1849.5	30 26		Capt. Kellett. Reference as above. In $\phi = 66° 16'$, $\lambda = 161° 48'$.
3	1880, August 31	26 49	E.	M. Baker, Coast and Geodetic Survey (W. H. Dall in charge of party), Chamisso Harbor. Position as in heading.

ANALYTICAL EXPRESSIONS OF THE OBSERVED DECLINATIONS.

The resulting empirical expressions for the secular variation of the magnetic declination, given in Table I, were derived from the preceding results of observation at the principal stations by applying to them the harmonic analysis, as explained in the preface. The stations are arranged geographically as far as practicable, and their positions are given by latitude and longitude (west of Greenwich). Total number of stations 64, and of observations about 750. The epoch to which the formulæ refer is 1850, January 1, or m = t — 1850.0

Table I (b) contains the results for subordinate stations, which necessarily cover a more restricted area, they depend upon an exponential function. Number of stations discussed 18, with an aggregate number of observations equal to 87.

TABLE I.—FORMULÆ EXPRESSING THE MAGNETIC DECLINATION AT VARIOUS PLACES AND FOR ANY TIME WITHIN THE LIMITS OF OBSERVATION; DEDUCED FROM THE PRECEDING COLLECTION OF RESULTS.

Name of station and locality.	Latitude.	Longitude.	Expression for magnetic declination.
	° ′	° ′	
Paris, France*	+ 48 50.2	− 2 20.2	$D = +6.479 + 16.002 \sin(0.765m + 118.78) + [0.7 + 0.4 \sin(0.69m + 276.6)] \sin(3.93m + 247$
Halifax, Nova Scotia	44 39.6	+ 63 35.3	$D = +16.49 + 4.08 \sin(1.1\ m + 44.7)$
Quebec, Canada	46 48.4	71 14.5	$D = +14.64 + 2.85 \sin(1.50\ m + 3.8) + 0.61 \sin(4.0m + 0.3)$
Montreal, Canada	45 30.5	73 34.9	$D = +11.83 + 4.17 \sin(1.5\ m - 18.5) + 0.53 \sin(4.9m + 19)$
York Factory, on Hudson Bay	57 00	92 26	$D = +4.97 + 14.14 \sin(1.4\ m - 90.9)$†
Eastport, Me	44 54.4	66 59.2	$D = +16.08 + 3.59 \sin(1.2\ m + 17.5)$
Portland, Me	43 38.8	70 16.6	$D = +10.72 + 2.68 \sin(1.33\ m + 24.1)$
Burlington, Vt	44 28.2	73 12.3	$D = +10.81 + 3.65 \sin(1.30\ m - 20.5) + 0.18 \sin(7.0m + 132)$
Rutland, Vt.	43 36.5	72 55.5	$D = +10.03 + 3.82 \sin(1.5\ m - 24.3)$
Portsmouth, N. H	43 04.8	70 43.0	$D = +10.63 + 3.17 \sin(1.44\ m - 4.7)$
Newburyport, Mass	42 48.4	70 49.0	$D = +10.07 + 3.10 \sin(1.4\ m + 1.9)$
Salem, Mass	42 31.9	70 52.5	$D = +9.80 + 3.61 \sin(1.50\ m - 1.0)$
Boston, Mass	42 21.5	71 03.8	$D = +9.52 + 2.93 \sin(1.30\ m + 5.0)$
Cambridge, Mass	42 22.9	71 07.7	$D = +9.58 + 2.69 \sin(1.3\ m + 7.0) + 0.18 \sin(3.2m + 44)$
Nantucket, Mass	41 17.0	70 06.0	$D = +9.29 + 2.78 \sin(1.35\ m + 5.5)$
Providence, R. I.	41 49.5	71 24.1	$D = +9.10 + 2.99 \sin(1.45\ m - 3.4) + 0.19 \sin(7.2m + 116)$
Hartford, Conn	41 45.9	72 40.4	$D = +8.06 + 2.90 \sin(1.25\ m - 26.4)$
New Haven, Conn	41 18.5	72 55.7	$D = +7.78 + 3.11 \sin(1.40\ m - 22.1)$
Albany, N. Y	42 39.2	73 45.8	$D = +8.17 + 3.02 \sin(1.44\ m - 8.3)$
Oxford, N. Y	42 26.5	75 40.5	$D = +6.19 + 3.24 \sin(1.35\ m - 18.9)$
Buffalo, N. Y	42 52.8	78 53.5	$D = +3.66 + 3.47 \sin(1.4\ m - 27.8)$
Toronto, Canada	43 39.4	79 23.4	$D = +3.60 + 2.82 \sin(1.4\ m - 44.7) + 0.09 \sin(9.3m + 136) + 0.08 \sin(19m + 247)$
Erie, Pa	42 07.8	80 05.4	$D = +2.26 + 2.71 \sin(1.55\ m - 29.7)$
Marietta, Ohio	39 25	81 28	$D = +0.02 + 2.89 \sin(1.4\ m - 40.5)$
Cleveland, Ohio	41 30.3	81 42.0	$D = +0\ 10 + 2.07 \sin(1.40\ m - 6.2)$
Detroit, Mich	42 20.0	83 03.0	$D = -0.97 + 2.21 \sin(1.50\ m - 15.3)$
Sault de Ste Marie, Mich	46 29.9	84 20.1	$D = +1.54 + 2.70 \sin(1.45\ m - 58.5)$
Cincinnati, Ohio	39 08.6	84 25.3	$D = -2.40 + 2.62 \sin(1.42\ m - 39.8)$
Saint Louis, Mo	38 38.0	90 12.2	$D = -7.15 + 2.33 \sin(1.4\ m - 20.1)$†
New York, N. Y.	40 42.7	74 00.4	$D = +6.40 + 2.29 \sin(1.6\ m - 5.5) + 0.14 \sin(6.3m + 64)$
Hatborough, Pa	40 12	75 07	$D = +5.23 + 3.28 \sin(1.54\ m - 13.2) + 0.22 \sin(4.1m + 157)$
Philadelphia, Pa	39 56.9	75 09.0	$D = +5.38 + 3.29 \sin(1.55\ m - 23.9) + 0.39 \sin(4.0m + 161)$
Harrisburg, Pa	40 15.9	76 52.9	$D = +2.93 + 2.98 \sin(1.50\ m + 0.2)$
Baltimore, Md	39 17.8	76 37.0	$D = +3.20 + 2.57 \sin(1.45\ m - 21.2)$
Washington, D. C	+38 53.3	+77 00.6	$D = +2.47 + 2.52 \sin(1.40\ m - 14.6)$

* Having come into possession of two recent values of the declination at Paris and rediscussing the series, which now extends over 338 years, two new features in the secular motion of the magnet were noticed, which possibly may be of importance in the ultimate explanation of the phenomenon, and which demanded a more complicated formula for its representation than that given in the general table above. After computing the principal periodic term, viz,

$$D = +6^\circ.479 + 16^\circ.002 \sin(0.765m + 118^\circ\ 46'.5)$$

the residuals between the computed and observed values showed the existence of a secondary wave, superposed upon the primary, having one if not two characteristics, viz, a variability in the parameter, that is, the secondary wave becoming smaller in height since about 1540, and apparently a variability in the length of its period; that is, the period of the superposed secondary wave was nearly constant in the second half of the sixteenth and throughout the seventeenth centuries, but afterwards diminished rapidly. Both variations are undoubtedly periodic, though from want of sufficient data for the present I preferred a limited diminution of the period. These features are shown on the accompanying diagram, Plate No. 36, lower figure, which exhibits the observed and computed values; but it will be noticed that there may be a doubt whether one or two waves lie between 1740 and 1870, and since the supposed diminution of the period hinges upon this, I prefer to give two expressions for the declination, viz, that given in the table above, giving one crest, and the other giving two crests during that period; they are:

$$D_{I} = +6^\circ.479 + 16^\circ.002 \sin(0.765m + 118^\circ\ 46'.5) + [0.7 + 0.4 \sin(0.69m + 276^\circ.6)] \sin(3.93m + 247^\circ)$$
$$D_{II} = +6^\circ.479 + 16^\circ.002 \sin(0.765m + 118^\circ\ 46'.5) + [0.7 - 0.4 \sin(0.69n)] \sin[(4.04 + .0054n + .000033n^2)n]$$

$D_{,}$ supposes a variable parameter and constant period of 91.6 years for the secondary wave; $D_{,,}$ supposes a variable parameter and variable length of period of secondary wave, diminishing from about 94.2 to 58.5 years at present. The results of the second formula are shown on the diagram, and the differences observed—computed values, are given in Table II for Paris, headed $O - C_{,}$ and $O - C_{,,}$. I shall leave it to future observations to decide which of the hypotheses is the better one.

† Approximate expression.

TABLE I.—Continued.

Name of station and locality.	Latitude.	Longitude.	Expression for magnetic declination.
	° ′	° ′	° ° °
Cape Henry, Va	+ 36 55.5	+ 76 00.5	D = + 2.54 + 2.41 sin (1.50 m − 35.4)
Charleston, S. C	32 46.6	79 55.8	D = − 2.14 + 2.74 sin (1.35 m − 1.3)
Savannah, Ga	32 04.9	81 05.5	D = − 2.54 + 2.32 sin (1.5 m − 28.6)
Key West, Fla	24 33.5	81 48.5	D = − 3.90 + 2.93 sin (1.4 m − 33.5)
Havana, Cuba	23 09.3	82 21.5	D = − 4.52 + 2.00 sin (1.3 m − 26.7)*
Kingston, Jamaica	17 55.9	76 50.6	D = − 4.64 + 2.04 sin (1.2 m + 15.9)
Panama, New Granada	8 57.1	79 32.2	D = − 6.80 + 1.82 sin (0.9 m + 10.4)*
Florence, Ala	34 47.2	87 41.5	D = − 4.25 + 2.33 sin (1.3 m − 52.8)
Mobile, Ala	30 41.4	88 02.5	D = − 4.40 + 2.69 sin (1.45 m − 76.4)
New Orleans, La	29 57.2	90 03.9	D = − 5.61 + 2.57 sin (1.4 m − 61.9)
Vera Cruz, Mexico	19 11.9	96 08.8	D = − 4.38 + 5.04 sin (1.10 m − 65.0)
Mexico, Mexico	19 25.9	99 06.0	D = − 4.34 + 4.44 sin (1.0 m − 79.2)
Acapulco, Mexico	16 50.5	99 52.3	D = − 4.13 + 4.82 sin (1.0 m − 81.1)
San Blas, Mexico	21 32.6	105 15.7	D = − 6.51 + 2.74 sin (0.9 m − 106.3)
Magdalena Bay, Lower Cal	24 38.4	112 08.9	D = − 7.52 + 3.27 sin (1.25 m − 140.6)
San Diego, Cal	32 42.1	117 14.3	D = − 12.52 + 1.60 sin (1.2 m − 179.8)
Monterey, Cal	36 36.1	121 53.6	D = − 12.90 + 3.28 sin (1.0 m − 142.6)
San Francisco, Cal	37 47.5	122 27.2	D = − 13.34 + 3.23 sin (1.00 m − 130.3)
Cape Disappointment, Wash. Ter	46 16.7	124 02.0	D = − 20.26 + 2.36 sin (1.25 m − 180.0)
Nee-ah Bay, Wash. Ter	48 21.8	124 38.0	D = − 20.44 + 2.33 sin (1.3 m − 142.3)
Nootka Sound, Vancouver Island	49 35.5	126 37.5	D = − 21.58 + 2.02 sin (1.3 m − 129.9)
Kailua, Sandwich Islands	19 37	156 01	D = − 4.76 + 4.51 sin (1.0 m − 68.3)
Honolulu, Sandwich Islands	21 18.2	157 55.0	D = − 4.94 + 5.39 sin (1.0 m − 76.4)
Sitka, Alaska	57 02.9	135 19.7	D = − 26.77 + 2.33 sin (1.4 m − 111.6)
Port Mulgrave, Yakutat Bay, Alaska	59 33.7	139 45.9	D = − 24.03 + 7.77 sin (1.3 m − 85.8)
Port Etches, Prince William Sound, Alaska	60 20.7	146 37.6	D = − 23.67 + 8.25 sin (1.4 m − 74.4)
St. Paul, Kadiak Island, Alaska	57 48.0	152 21.3	D = − 22.56 + 4.83 sin (1.4 m − 71.9)
Unalashka, Alaska	53 52.6	166 31.5	D = − 18.34 + 1.45 sin (1.4 m − 67.8)
Petropavlovsk, Kamtchatka	+ 53 01	+ 201 17	D = − 3.35 + 2.97 sin (1.3 m + 12.2)

* Approximate expression.

TABLE I (*b*).—EXPRESSIONS FOR THE MAGNETIC DECLINATION AT SUBORDINATE STATIONS.

Name of station.	Latitude.	Longitude.	Limits of observations.	Expression for magnetic declination.
	° ′	° ′		°
St. John's, Newfoundland	+47 34.4	+52 41.9	1844—1881	$D = +30.35 + .1080\,(t-1850) - .00325\,(t-1850)^2$
Charlotte Town, Prince Edward Island	46 14	63 27	1842—1862	$D = +22.07 + .1124\,(t-1850) - .00232\,(t-1850)^2$
Tyrone, Pa	40 40	78 15.5	1871—1879	$D = +3.46 + .0550\,(t-1875.5)$
Pittsburgh, Pa	40 27.6	80 00.8	1840—1878	$D = +2.36 + .0566\,(t-1878.7)$
Chicago, Ill	41 50.0	87 36.7	1823—1878	$D = -6.03 + .0281\,(t-1850) + .00082\,(t-1850)^2$
Grand Haven, Mich	43 05.2	86 12.6	1825—1880	$D = -4.95 + .0380\,(t-1850) + .00120\,(t-1850)^2$
Madison, Wis	43 04.6	89 24.2	1878—1881	$D = -6.43 + .0655\,(t-1880.3)$
Michipicoten, Ontario, Canada	47 56.0	84 50.6	1824—1880	$D = -3.38 + .0950\,(t-1850) + .00192\,(t-1850)^2$
Duluth, Minn., and Superior City, Wis	46 45.5	92 04.5	1870—1880	$D = -10.17 + .0868\,(t-1875.8)$
St. George's Town, Bermuda Islands	+32 23	64 42	1831—1876	$D = +6.95 + .0145\,(t-1850) + .00061\,(t-1850)^2$
Rio Janeiro, Brazil	−22 54.8	43 09.5	1768—1876	$D = +0.282 + .1395\,(t-1850) + .000545\,(t-1850)^2$
San Antonio, Tex	+29 25.4	98 29.3	1825—1878	$D = -10.14 + .0204\,(t-1850) + .00024\,(t-1850)^2$
Omaha, Nebr., and Council Bluffs, Iowa	41 15.7	95 56.5	1869—1880	$D = -11.66 + .0439\,(t-1850)$
Denver, Colo	39 45.3	104 59.5	1866—1878	$D = -14.79 + .0258\,(t-1872.9)$
Salt Lake City, Utah	40 46.1	111 53.8	1850—1881	$D = -15.51 - .0930\,(t-1850) + .00180\,(t-1850)^2$
Port Townshend, Wash. Ter	48 07.0	122 44.9	1841—1881	$D = -21.38 - .0730\,(t-1850) + .00209\,(t-1850)^2$
Port Clarence, Alaska	65 17	166 19	1827—1880	$D = -26.39 + .0640\,(t-1850) + .00178\,(t-1850)^2$
Chamisso Island, Alaska	+66 13	+161 49	1826—1880	$D = -30.40 + .0527\,(t-1850) + .00209\,(t-1850)^2$

In the second table are exhibited for each locality discussed: in column (1) the year and fraction of a year when the observations were made; in columns (2) and (3) the observed and computed declinations, the latter by the preceding formulæ; and in column (4) the differences of these values in the sense of observed minus computed values. Table II (*b*) gives the comparisons between observation and computation for the subordinate stations.

TABLE II.—COMPARISON OF OBSERVED AND COMPUTED MAGNETIC DECLINATIONS.

PARIS, FRANCE.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n C_I	Comp'd decl'n C_{II}	$O - C_I$	$O - C_{II}$
	°	°	°	°	°
1541.5	− 7.00	− 6.79	− 6.68	−0.21	−0.32
1550.5	8.00	7.99	7.66	−0.01	−0.34
1580.5	11.50	10.61	10.59	−0.89	−0.91
1603.5	8.75	8.59	8.73	−0.16	−0.02
1610.5	8.00	7.49	7.63	−0.51	−0.37
1630.5	4.50	4.63	4.63	+0.13	+0.13
1642.5	2.50	3.32	3.17	+0.82	+0.67
1660.0	1.50	1.28	1.06	−0.22	−0.44
1664.5	− 0.67	0.58	− 0.39	−0.09	−0.28
1667.0	+ 0.13	− 0.14	+ 0.01	+0.27	+0.12
1670.5	1.50	+ 0.52	0.63	+0.98	+0.87
1682.5	3.13	3.24	3.16	−0.11	−0.03
1687.5	4.87	4.52	4.35	+0.35	+0.52
1695.1	6.62	6.53	6.32	+0.09	+0.30
1703.5	9.00	8.72	8.50	+0.28	+0.50
1712.5	11.18	10.87	10.74	+0.31	+0.44
1721.5	12.87	12.71	12.68	+0.16	+0.19
1730.5	14.62	14.25	14.28	+0.37	+0.34
1739.5	15.38	15.56	15.58	−0.18	−0.20
1748.5	16.62	16.77	16.76	−0.15	−0.14
1757.1	17.82	17.88	17.86	−0.06	−0.04
1765.5	19.00	19.01	19.09	−0.01	−0.09
1772.5	20.02	19.90	20.09	+0.12	−0.07
1779.5	20.67	20.76	21.04	−0.09	−0.37
1784.5	21.42	21.33	21.62	+0.09	−0.20
1791.5	22.30	21.96	22.19	+0.34	+0.11
1800.0	22.23	22.54	22.52	−0.31	−0.29
1803.5	21.97	22.68	22.52	−0.71	−0.55
1805.5	22.08	22.74	22.50	−0.66	−0.42
1807.5	22.57	22.77	22.46	−0.20	+0.11
1812.2	22.33	22.79	22.34	−0.46	−0.01
1816.5	22.37	22.74	22.19	−0.37	+0.18
1827.2	22.25	22.28	21.93	−0.03	+0.32
1835.5	22.07	21.68	21.77	+0.39	+0.30
1838.2	21.63	21.43	21.68	+0.20	−0.05
1842.5	21.48	21.01	21.46	+0.47	+0.02
1858.0	19.60	19.29	19.59	+0.31	+0.01
1865.5	18.73	18.36	18.30	+0.37	+0.43
1869.7	17.14	17.83	17.69	−0.69	−0.55
1875.5	17.35	17.05	16.97	+0.30	+0.38
1879.0	+16.93	+16.57	+16.60	+0.36	+0.33

HALIFAX, NOVA SCOTIA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
	°	°	°
1700.0	+13.00	+12.97	+0.03
1756.5	12.83	13.03	− .20
1775.5	13.58	14.02	− .44
1798.5	16.50	15.65	+ .85
1818.0	17.47	17.16	+ .31
1821.7	17.60	17.45	+ .15
1852.5	18.17	19.50	−1.33
1853.9	18.85	19.52	−0.67
1860.5	19.92	19.88	+0.04
1866.3	21.09	20.11	+0.98
1879.7	+20.72	+20.47	+0.25

QUEBEC, CANADA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
	°	°	°
1642.5	+16.00	+16.33	−0.33
1686.5	15.50	17.70	−2.20
1700.0	16.00	17.05	−1.05
1785.5	12.58	12.39	+0.19
1789.5	11.75	12.33	−0.58
1791.5	13.00	12.29	+0.71
1792.3	12.42	12.29	+0.13
1793.7	12.54	12.26	+0.28
1805.3	11.58	12.08	−0.50
1810.5	11.63	12.06	−0.43
1811.5	+12.25	+12.06	+0.19

QUEBEC, CANADA—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
	°	°	°
1814.5	+11.83	+12.10	−0.27
1820.8	12.54	12.27	+0.27
1821.7	12.90	12.30	+0.60
1822.2	13.00	12.32	+0.68
1823.6	13.00	12.38	+0.62
1824.2	12.67	12.42	+0.25
1831.7	13.40	12.91	+0.49
1832.4	13.00	12.97	+0.03
1833.5	12.75	13.07	−0.32
1834.4	13.31	13.15	+0.16
1835.9	13.17	13.28	−0.11
1839.3	13.37	13.63	−0.26
1840.5	13.71	13.75	−0.04
1842.7	14.02	13.98	+0.04
1846.5	14.53	14.42	+0.11
1847.7	14.64	14.56	+0.08
1848.5	14.58	14.65	−0.07
1849.4	15.37	14.77	+0.60
1850.3	15.25	14.86	+0.39
1851.7	15.00	15.03	−0.03
1853.1	15.50	15.19	+0.31
1858.8	15.57	15.82	−0.25
1859.5	16.28	15.90	+0.38
1860.8	16.47	16.02	+0.45
1865.5	16.67	16.47	+0.20
1879.7	+17.23	+17.30	−0.07

MONTREAL, CANADA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
1749.5	+10.63	+10.55	+0.08
1785.5	8.40	8.58	−0.18
1793.6	8.25	8.28	−0.03
1814.5	7.75	7.65	+0.10
1834.5	8.00	8.60	−0.60
1835.5	9.83	8.71	+1.12
1842.6	8.97	9.60	−0.63
1859.5	12.35	12.01	+0.34
1879.7	+13.67	+13.79	−0.12

YORK FACTORY, HUDSON BAY.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
1725.5	+19.0	+19.05	− .05
1787.5	+ 5.0	+ 4.57	+ .43
1819.7	− 6.0	− 5.31	+ .69
1843.5	− 9.42	− 8.96	− .46
1857.6	− 7.62	− 8.97	+1.35
1879.0	− 6.50	− 5.90	−0.60

EASTPORT, ME.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
1775.5	+12.67	+12.67	.00
1860.8	17.95	17.90	+ .05
1861.5	17.99	17.95	+ .04
1862.5	18.01	18.01	.00
1863.5	18.04	18.07	− .03
1864.3	+18.06	+18.12	− .06

EASTPORT, ME.—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
	°	°	°
1865.5	+18.10	+18.19	− .09
1873.7	18.93	18.66	+ .27
1879.7	+19.13	+18.95	+ .18

PORTLAND, ME.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
1763.5	+ 7.75	+ 8.05	− .30
1775.5	8.50	8.14	+ .36
1845.4	11.47	11.55	− .08
1851.6	11.69	11.91	− .22
1859.5	12.33	12.33	.00
1863.5	12.47	12.52	− .05
1864.8	12.73	12.58	+ .15
1865.5	12.71	12.61	+ .10
1866.1	12.72	12.64	+ .08
1873.7	+12.89	+12.94	− .05

BURLINGTON, VT.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
1793.5	+ 7.63	+ 7.35	+0.28
1805.5	6.20	7.22	−1.02
1818.5	7.50	7.43	+ .07
1822.5	7.70	7.62	+ .08
1826.5	7.60	7.88	− .28
1830.5	8.17	8.18	− .01
1831.5	8.25	8.26	− .01
1832.5	8.42	8.34	+ .08
1834.5	8.83	8.50	+ .33
1837.5	8.75	8.75	.00
1845.5	9.37	9.37	.00
1855.7	9.95	10.01	− .06
1873.8	+11.32	+11.31	+ .01

RUTLAND, VT.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
1789.3	+ 7.05	+ 6.58	+ .47
1810.4	6.07	6.23	− .16
1811.7	6.02	6.25	− .23
1859.6	9.82	9.37	+ .45
1873.8	10.67	10.79	− .12
1879.8	+11.15	+11.36	− .21

PORTSMOUTH, N. H.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
1771.5	+ 7.77	+ 7.82	− .05
1775.5	7.75	7.69	+ .06
1844.5	9.78	9.94	− .16
1850.7	10.50	10.42	+ .08
1859.5	11.25	11.12	+ .13
1879.6	+12.52	+12.58	− .06

NEWBURYPORT, MASS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
1775.5	+ 6.75	+ 7.04	− .29
1781.5	7.30	6.98	+ .32
1850.7	10.09	10.23	− .14
1859.5	+10.97	+10.88	+ .09

TABLE II—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
SALEM, MASS.			
	°	°	°
1781.6	+ 6.90	+ 6.29	+ .61
1805.8	5.95	6.47	– .52
1810.5	6.09	6.67	– .58
1849.6	10.24	9.70	+ .54
1855.6	10.83	10.27	+ .56
1877.5	+11.50	+12.13	– .63
BOSTON, MASS.			
1700.5	+10.0	+10.00	.00
1708.5	9.0	9.47	– .47
1741.5	7.50	7.48	+ .02
1776.0	7.67	6.59	+1.08
1782.5	7.00	6.61	+0.39
1793.5	6.50	6.80	–0.30
1807.5	6.08	7.27	–1.19
1839.5	9.10	9.07	+0.03
1846.7	9.52	9.56	–0.04
1855.6	10.23	10.14	+0.09
1872.7	11.25	11.18	+0.07
1877.5	+11.60	+11.43	+0.17
CAMBRIDGE, MASS.			
1708.5	+ 9.0	+ 9.30	– .30
1742.5	8.0	7.70	+ .30
1757.5	7.33	7.28	+ .05
1761.5	7.23	7.17	+ .06
1763.5	7.00	7.13	– .13
1780.5	7.03	6.90	+ .13
1782.5	6.75	6.89	– .14
1783.5	6.87	6.90	– .03
1788.5	6.63	6.93	– .30
1810.5	7.50	7.52	– .02
1835.5	8.85	9.02	– .17
1837.5	9.15	9.15	.00
1840.4	9.30	9.36	– .06
1842.2	9.57	9.49	+ .08
1844.5	9.65	9.65	.00
1845.4	9.53	9.72	– .19
1850.6	9.50	10.07	– .57
1852.5	10.13	10.20	– .07
1854.5	10.21	10.33	– .12
1855.4	10.91	10.39	+ .52
1856.5	10.47	10.46	+ .01
1859.2	10.80	10.63	+ .17
1867.5	10.70	11.09	– .39
1879.6	+11.77	+11.62	+ .15
NANTUCKET, MASS.			
1775.5	+ 6.50	+ 6.52	– .02
1834.5	8.45	8.55	– .10
1838.9	9.04	8.83	+ .21
1842.7	9.15	9.08	+ .07
1843.7	9.17	9.15	+ .02
1846.6	+ 9.23	+ 9.33	– .10
NANTUCKET, MASS.—Continued.			
	°	°	°
1855.6	+ 9.97	+ 9.92	+ .05
1867.4	10.33	10.64	– .31
1879.6	+11.46	+11.27	+ .19
PROVIDENCE, R. I.			
1717.5	+ 9.60	+ 9.73	– .13
1769.5	6.50	6.29	+ .21
1815.5	6.50	6.55	– .05
1819.5	6.62	6.75	– .13
1835.5	7.57	7.90	– .33
1840.5	8.42	8.36	+ .06
1841.5	8.52	8.45	+ .07
1842.5	8.65	8.53	+ .12
1843.5	8.77	8.60	+ .17
1855.6	+ 9.52	+ 9.42	+ .10
HARTFORD, CONN.			
1786.5	+ 5.42	+ 5.28	+ .14
1810.5	4.77	5.25	– .48
1824.5	5.75	5.60	+ .15
1829.0	6.05	5.76	+ .29
1859.6	7.29	7.34	– .05
1867.6	7.82	7.84	– .02
1879.6	+ 8.57	+ 8.59	– .02
NEW HAVEN, CONN.			
1761.5	+ 5.78	+ 6.04	– .26
1775.5	5.42	5.28	+ .14
1780.5	5.25	5.07	+ .18
1811.5	5.17	4.76	+ .41
1819.8	4.42	4.97	– .55
1828.5	5.28	5.32	– .04
1835.3	5.68	5.67	+ .01
1836.5	5.92	5.74	+ .18
1837.9	5.83	5.82	+ .01
1840.5	6.17	5.98	+ .19
1844.6	5.75	6.24	– .49
1845.7	6.29	6.32	– .03
1848.6	6.58	6.51	+ .07
1855.6	7.05	7.01	+ .04
1872.5	8.46	8.29	+ .17
1878.5	+ 8.69	+ 8.73	– .04
ALBANY, N. Y.			
1817.8	+ 5.73	+ 5.71	+ .02
1818.6	5.75	5.74	+ .01
1825.3	6.00	6.08	– .08
1828.6	6.27	6.26	+ .01
1830.5	6.30	6.38	– .08
1831.6	6.54	6.45	+ .09
1834.8	6.67	6.65	+ .02
1836.8	6.78	6.78	.00
1847.9	+ 7.58	+ 7.58	.00
ALBANY, N. Y.—Continued.			
	°	°	°
1855.7	+ 7.91	+ 8.17	– .26
1856.7	8.58	8.24	+ .34
1858.4	8.28	8.37	– .09
1879.6	+ 9.86	+ 9.87	– .01
OXFORD, N. Y.			
1794.0	+ 3.0	+ 2.96	+ .04
1817.5	3.0	3.31	– .31
1828.5	4.50	3.79	+ .71
1834.8	3.87	4.13	– .26
1836.8	4.15	4.26	– .11
1837.5	4.50	4.30	+ .20
1838.5	4.45	4.36	+ .09
1849.9	5.18	5.14	+ .04
1857.3	5.73	5.68	+ .05
1858.1	5.78	5.74	+ .04
1859.0	5.83	5.81	+ .02
1873.9	6.87	6.94	– .07
1874.4	+ 6.93	+ 6.97	– .04
BUFFALO, N. Y.			
1797.5	+ 0.00	+ 0.26	– .26
1798.5	0.50	0.24	+ .26
1837.5	1.42	1.19	+ .23
1839.5	1.25	1.31	– .06
1845.5	1.42	1.71	– .29
1859.5	2.94	2.79	+ .15
1872.5	3.87	3.89	– .02
1873.5	+ 3.97	+ 3.97	.00
TORONTO, CANADA.			
1840.1	+ 1.45	+ 1.36	+ .09
1841.5	1.24	1.40	– .16
1842.5	1.32	1.45	– .13
1845.5	1.48	1.52	– .04
1846.5	1.51	1.54	– .03
1847.5	1.55	1.56	– .01
1848.5	1.59	1.57	+ .02
1849.5	1.62	1.59	+ .03
1850.5	1.64	1.62	+ .02
1851.5	1.68	1.66	+ .02
1853.5	1.77	1.76	+ .01
1854.5	1.80	1.82	– .02
1855.5	1.87	1.88	– .01
1856.5	1.94	1.95	– .01
1857.5	2.01	2.02	– .01
1858.5	2.07	2.08	– .01
1859.5	2.12	2.14	– .02
1860.5	2.18	2.20	– .02
1861.5	2.24	2.25	– .01
1862.5	2.26	2.29	– .03
1863.5	2.32	2.33	– .01
1864.5	2.36	2.37	– .01
1865.5	2.41	2.41	.00
1866.5	+ 2.46	+ 2.45	+ .01
TORONTO, CANADA—Continued.			
	°	°	°
1867.5	+ 2.50	+ 2.50	.00
1868.5	2.55	2.55	.00
1869.5	2.62	2.62	.00
1870.5	2.70	2.69	+ .01
1871.5	2.80	2.78	+ .02
1872.5	2.88	2.88	.00
1873.5	2.97	2.98	– .01
1874.5	3.07	3.09	– .02
1875.5	3.19	3.20	– .01
1876.5	3.31	3.30	+ .01
1877.5	3.41	3.41	.00
1878.5	3.52	3.50	+ .02
1879.5	3.62	3.58	+ .04
1880.8	+ 3.68	+ 3.67	+ .01
ERIE, PA.			
1786.8	+ 0.53	+ 0.12	+ .41
1795.5	– 0.72	– 0.21	– .51
1841.6	+ 0.50	+ 0.42	+ .08
1855.5	1.55	1.28	+ .27
1859.4	1.65	1.55	+ .10
1862.6	1.55	1.78	– .23
1867.3	2.22	2.12	+ .10
1873.6	2.31	2.59	– .28
1876.5	2.83	2.79	+ .04
1877.9	+ 3.00	+ 2.89	+ .11
MARIETTA, OHIO.			
1810.5	– 2.60	– 2.86	+ .26
1824.0	3.42	2.79	– .63
1838.5	1.54	2.39	+ .85
1845.3	2.42	2.10	– .32
1850.5	1.42	1.83	+ .41
1864.1	– 1.21	– 1.01	– .20
1881.4	+ 0.20	+ 0.20	.00
CLEVELAND, OHIO.			
1796.7	– 2.00	– 1.95	– .05
1830.5	1.33	1.04	– .29
1831.6	1.25	1.00	– .25
1834.1	0.83	0.89	+ .06
1838.1	0.58	0.70	+ .12
1840.5	0.32	0.59	+ .27
1841.3	0.09	0.55	+ .46
1845.5	– 0.65	– 0.35	– .30
1859.5	+ 0.77	+ 0.36	+ .41
1871.8	0.54	0.95	– .41
1872.5	0.75	0.98	– .23
1873.5	0.85	1.03	– .18
1880.5	+ 1.64	+ 1.33	+ .31
DETROIT, MICH.			
1810.5	– 2.80	– 3.10	+ .30
1822.5	– 3.22	– 2.82	– .40

TABLE II—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
DETROIT, MICH.—Continued.			
	°	°	°
1828.5	− 2.83	− 2.60	− .23
1835.5	2.17	2.30	+ .13
1840.5	1.97	2.06	+ .09
1859.5	0.70	1.01	+ .31
1865.5	0.67	0.66	− .01
1872.4	0.42	0.28	− .14
1873.4	0.29	0.22	− .07
1876.4	− 0.08	− 0.06	− .02
SAULT DE STE. MARIE, MICH.			
1790.0	0.00	+ 0.01	− .01
1843.5	− 1.13	− 0.96	− .17
1845.5	0.77	0.91	+ .14
1846.8	0.67	0.87	+ .20
1856.7	− 0.54	− 0.49	− .05
1873.6	+ 0.08	+ 0.43	− .35
1879.8	1.02	0.82	+ .20
1880.6	+ 0.99	+ 0.88	+ .11
CINCINNATI, OHIO.			
1806.5	− 4.97	− 4.97	.00
1810.5	5.00	5.01	+ .01
1840.0	4.77	4.52	− .25
1845.3	4.07	4.30	+ .23
1880.9	− 2.24	− 2.21	− .03
ST. LOUIS, MO.			
1819.5	−10.79	− 9.22	−1.57
1837.0	8.29	8.59	+ .30
1856.1	7.20	7.62	+ .42
1872.6	6.63	6.69	+ .06
1877.5	6.51	6.41	− .10
1878.6	6.56	6.36	− .20
1879.7	− 6.22	− 6.30	+ .08
NEW YORK, N. Y.			
1684.5	+ 8.75	+ 8.77	− .02
1686.5	9.00	8.77	+ .23
1691.5	8.75	8.65	+ .10
1724.0	7.33	7.47	− .14
1750.5	6.37	5.82	+ .55
1755.5	5.00	5.43	− .43
1789.5	4.33	4.27	+ .06
1824.5	4.67	4.61	+ .06
1834.5	4.83	5.14	− .31
1837.5	5.67	5.34	+ .33
1840.6	5.45	5.58	− .13
1841.5	6.10	5.65	+ .45
1844.6	6.22	5.89	+ .33
1845.7	6.42	5.98	+ .44
1846.3	5.56	6.02	− .46
1847.8	5.68	6.13	− .45
1855.6	6.72	6.70	+ .02
1860.7	+ 6.73	+ 7.00	− .27

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
NEW YORK, N. Y.—Continued.			
	°	°	°
1873.8	+ 7.52	+ 7.56	− .04
1874.6	7.38	7.59	− .21
1879.5	+ 7.90	+ 7.80	+ .10
HATBOROUGH, PA.			
1680.5	+ 8.47	+ 8.49	− .02
1690.5	8.25	8.30	− .05
1700.5	7.92	7.94	− .02
1710.5	7.47	7.49	− .02
1720.5	7.00	6.95	+ .05
1730.5	6.42	6.30	+ .12
1740.5	5.58	5.56	+ .02
1750.5	4.92	4.67	+ .25
1760.5	4.00	3.75	+ .25
1770.5	2.92	2.89	+ .03
1780.5	2.08	2.21	− .13
1790.5	1.83	1.84	− .01
1800.5	1.92	1.79	+ .13
1810.5	2.00	2.07	− .07
1820.5	2.45	2.56	− .11
1830.5	3.00	3.20	− .20
1840.5	3.83	3.89	− .06
1850.5	+ 4.42	+ 4.60	− .18
PHILADELPHIA, PA.			
1701.5	+ 8.50	+ 8.17	+ .33
1710.5	8.50	8.00	+ .50
1750.5	5.75	5.59	+ .16
1793.5	1.50	1.97	− .47
1802.5	1.50	1.94	− .44
1804.5	2.08	1.97	+ .11
1813.5	2.43	2.22	+ .21
1837.5	3.87	3.49	+ .38
1840.5	3.62	3.65	− .03
1841.7	3.90	3.72	+ .18
1846.4	3.85	3.97	− .12
1855.7	4.53	4.49	+ .04
1862.6	5.00	4.92	+ .08
1872.8	5.46	5.66	− .20
1877.7	+ 6.04	+ 6.06	− .02
HARRISBURG, PA.			
1795.6	− 0.43	− 0.02	− .41
1840.5	+ 3.21	+ 2.21	+1.00
1843.5	2.58	2.44	+0.14
1854.8	3.01	3.31	− .30
1857.4	3.32	3.51	− .19
1861.0	3.50	3.79	− .29
1862.6	3.74	3.90	− .16
1874.8	4.85	4.74	+ .11
1876.9	5.17	4.86	+ .31
1877.7	+ 4.89	+ 4.91	− .02
BALTIMORE, MD.			
1679.0	+ 5.25	+ 5.77	− .52
1683.5	+ 6.25	+ 5.75	+ .50

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
BALTIMORE, MD.—Continued.			
	°	°	°
1703.5	+ 5.12	+ 5.27	− .15
1720.5	4.21	4.45	− .24
1729.2	4.02	3.93	+ .09
1754.5	2.28	2.31	− .03
1756.9	2.88	2.16	+ .72
1771.0	1.11	1.41	− .30
1776.1	1.75	1.19	+ .56
1780.5	0.77	1.02	− .25
1787.5	0.37	0.82	− .45
1808.5	0.21	0.66	− .45
1840.7	2.27	1.76	+ .51
1847.3	2.31	2.11	+ .20
1856.7	2.49	2.69	− .20
1875.5	3.74	3.90	− .16
1877.8	+ 4.18	+ 4.04	+ .14
WASHINGTON, D. C.			
1792.5	− 0.24	− 0.04	− .20
1809.9	+ 0.87	0.09	− .78
1841.0	1.34	1.32	+ .02
1842.0	1.40	1.37	+ .03
1855.5	2.40	2.17	+ .23
1856.6	2.36	2.23	+ .13
1857.2	2.41	2.27	+ .14
1860.7	2.44	2.49	− .05
1862.7	2.66	2.61	+ .05
1863.6	2.70	2.66	+ .04
1866.8	2.74	2.86	− .12
1867.5	2.80	2.90	− .10
1868.5	2.85	2.96	− .11
1869.3	2.88	3.01	− .13
1870.5	2.89	3.08	− .19
1871.5	2.95	3.14	− .19
1872.5	3.00	3.20	− .20
1873.5	3.00	3.26	− .26
1874.5	3.11	3.32	− .21
1875.5	3.26	3.38	− .12
1876.3	3.31	3.42	− .11
1877.5*	3.66	3.49	+ .17
1878.6	3.75	3.55	+ .20
1879.4	3.84	3.60	+ .24
1880.3	3.92	3.64	+ .28
1882.5	+ 3.93	+ 3.77	+ .16
CAPE HENRY, VA.			
1730.0	+ 4.0	+ 3.93	+ .07
1809.5	− 0.13	0.14	− .27
1832.5	+ 0.75	0.42	+ .33
1856.7	1.47	1.51	− .04
1874.9	2.66	2.62	+ .04
1879.4	+ 2.75	+ 2.90	− .15
CHARLESTON, S. C.			
1775.5	− 3.80	− 4.84	+1.04
1784.1	− 5.25	− 4.88	−0.37

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
CHARLESTON, S. C.—Continued.			
	°	°	°
1785.8	− 5.75	− 4.88	− .87
1825.0	3.75	3.72	− .03
1837.5	2.90	2.99	+ .09
1840.5	2.73	2.88	+ .15
1841.4	2.40	2.75	+ .35
1847.8	2.25	2.35	+ .10
1849.3	2.28	2.24	− .04
1874.4	0.97	0.70	− .27
1880.1	− 0.43	− 0.43	.00
SAVANNAH, GA.			
1817.5	− 4.0	− 4.68	+ .68
1839.0	4.30	4.18	− .12
1852.3	3.67	3.52	− .15
1857.3	3.46	3.24	− .22
1874.2	− 1.98	− 2.23	+ .25
KEY WEST, FLA.			
1829.1	− 6.42	− 6.50	+ .08
1843.5	6.03	5.88	− .15
1849.6	5.48	5.54	+ .06
1860.7	4.78	4.83	+ .05
1861.2	4.74	4.80	+ .06
1862.7	4.67	4.69	+ .02
1863.5	4.61	4.64	+ .03
1864.5	4.57	4.57	.00
1865.5	4.53	4.50	− .03
1866.2	4.50	4.45	− .05
1879.2	− 3.56	− 3.52	− .04
HAVANA, CUBA.			
1726.5	− 4.4	− 4.27	− .13
1732.3	4.5	4.53	+ .03
1815.5	7.0	6.42	− .58
1816.6	5.5	6.40	+ .90
1857.1	5.25	5.12	− .13
1858.5	5.75	5.05	− .70
1879.2	− 3.90	− 4.13	+ .23
KINGSTON, JAMAICA.			
1732.2	− 6.0	− 6.30	+ .30
1791.8	6.78	6.29	− .49
1806.0	6.5	5.86	− .64
1820.5	4.8	5.32	+ .52
1822.5	4.9	5.24	+ .34
1832.5	5.2	4.82	− .38
1833.5	4.7	4.78	+ .08
1837.8	4.3	4.59	+ .29
1847.3	3.67	4.19	+ .52
1857.2	3.67	3.79	+ .12
1876.0	− 3.79	− 3.14	− .65
PANAMA, NEW GRANADA.			
1775.8	− 7.82	− 8.32	+ .50
1790.8	7.82	8.04	+ .22
1802.5	− 8.0	− 7.77	− .23

* Change of station between 1876 and 1877.

TABLE II—Continued.

PANAMA, NEW GRANADA—Cont'd.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1822.5	– 7.0	– 7.25	+ .25
1837.5	7.03	6.83	– .20
1849.5	7.08	6.48	– .60
1858.5	6.28	6.24	– .04
1866.4	5.93	6.03	+ .10
1874.0	– 6.58	– 5.84	– .74

FLORENCE, ALA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1818.5	– 6.58	– 6.58	.00
1835.5	6.47	6.46	– .01
1865.3	5.40	5.51	+ .11
1875.4	5.24	5.04	– .20
1881.7	– 4.63	– 4.72	+ .09

MOBILE, ALA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1814.5	– 6.50	– 6.52	+ .02
1835.5	7.20	7.07	– .13
1840.5	7.08	7.09	+ .01
1843.5	6.93	7.08	+ .15
1847.4	7.07	7.05	– .02
1857.1	6.87	6.86	– .01
1875.4	– 6.12	– 6.11	– .01

NEW ORLEANS, LA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1720.5	– 2.0	– 3.31	+1.31
1768.5	7.83	5.79	–2.04
1796.5	5.10	7.37	+2.27
1806.5	8.05	7.77	–0.28
1840.5	8.33	8.10	–0.23
1857.0	8.00	7.69	–0.31
1858.3	7.86	7.59	–0.27
1870.5	7.10	7.02	–0.08
1872.1	6.66	6.93	+0.27
1880.2	– 6.46	– 6.47	+0.01

VERA CRUZ, MEXICO.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1727.0	– 2.25	– 2.63	+ .38
1769.4	6.57	6.61	+ .04
1776.5	7.50	7.21	– .29
1815.5	10.62	9.29	–1.33
1819.3	9.27	9.36	+ .09
1839.5	8.37	9.28	+ .91
1856.6	8.28	8.64	+ .36
1861.0	8.33	8.40	+ .07
1880.1	– 7.44	– 7.04	– .40

MEXICO, MEXICO.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1769.7	– 5.46	– 5.89	+ .43
1775.5	6.70	6.31	– .39
1804.0	8.13	7.97	– .16
1849.5	8.50	8.71	+ .21
1850.5	– 8.59	– 8.70	+ .11

MEXICO, MEXICO—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1856.9	– 8.77	– 8.57	– .20
1858.5	8.37	8.53	+ .16
1860.5	8.50	8.48	– .02
1862.5	8.46	8.42	– .04
1867.0	8.15	8.27	+ .12
1868.5	8.17	8.21	+ .04
1879.8	– 8.58	– 7.71	– .87

ACAPULCO, MEXICO.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1744.5	– 3.0	– 3.58	+ .58
1791.3	7.73	7.24	– .49
1822.5	8.67	8.70	+ .03
1828.5	9.12	8.83	– .29
1838.0	8.29	8.95	+ .66
1866.5	8.37	8.48	+ .11
1874.2	8.64	8.17	– .47
1880.9	– 7.94	– 7.83	– .11

SAN BLAS, MEXICO.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1791.3	– 7.47	– 7.49	+ .02
1822.0	8.67	8.56	– .11
1837.5	8.85	8.94	+ .09
1838.5	8.79	8.96	+ .17
1839.5	9.00	8.98	– .02
1841.5	9.20	9.01	– .19
1874.1	9.14	9.24	+ .10
1880.9	– 9.30	– 9.20	– .10

MAGDALENA BAY, LOWER CAL.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1837.5	– 8.27	– 8.84	+ .57
1839.5	9.25	8.97	– .28
1866.4	10.67	10.35	– .32
1871.3	11.00	10.51	– .49
1873.3	10.56	10.56	.00
1881.1	–10.48	–10.72	+ .24

SAN DIEGO, CAL.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1792.5	–11.0	–11.03	+ .03
1839.5	12.34	12.18	– .16
1851.3	12.48	12.57	+ .09
1853.8	12.53	12.65	+ .12
1866.4	13.16	13.06	– .10
1872.9	13.32	13.26	– .06
1881.3	–13.46	–13.50	+ .04

MONTEREY, CAL.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1786.7	–11.8	–11.47	– .33
1791.7	10.93	11.73	+ .80
1794.9	12.37	11.90	– .47
1837.5	14.50	14.28	– .22
1839.5	14.22	14.38	+ .16
1841.5	–15.00	–14.48	– .52

MONTEREY, CAL.—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1843.5	–14.00	–14.59	+ .59
1851.1	14.97	14.94	– .03
1854.4	14.98	15.08	+ .10
1873.7	15.92	15.77	– .15
1881.3	–15.90	–15.96	+ .06

SAN FRANCISCO, CAL.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1792.9	–12.8	–12.92	+ .12
1818.7	15.00	14.36	– .64
1827.5	15.45	14.81	– .64
1829.9	14.92	14.94	+ .02
1830.5	14.85	14.96	+ .11
1837.5	15.17	15.29	+ .12
1839.5	15.33	15.38	+ .05
1841.9	15.50	15.48	– .02
1850.0	15.68	15.80	+ .12
1852.3	15.48	15.88	+ .40
1858.4	15.88	16.08	+ .20
1866.5	16.42	16.29	– .13
1871.9	16.39	16.40	+ .01
1872.8	16.43	16.41	– .02
1873.7	16.41	16.43	+ .02
1874.0	16.45	16.43	– .02
1879.2	16.57	16.50	– .07
1880.8	16.56	16.52	– .04
1881.5	–16.48	–16.53	+ .05

CAPE DISAPPOINTMENT, WASH. TER.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1786.7	–18.0	–17.94	– .06
1792.3	18.0	18.01	+ .01
1839.5	19.18	19.72	+ .54
1842.5	20.00	19.88	– .12
1851.5	20.54	20.34	– .20
1858.5	21.00	20.69	– .31
1873.8	21.44	21.43	– .01
1881.8	–21.60	–21.77	+ .17

NEE-AH BAY, WASH. TER.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1792.3	–18.0	–19.03	+1.03
1841.5	22.50	21.49	–1.01
1852.6	21.50	21.97	+0.47
1855.6	21.80	21.09	+0.29
1881.8	–22.74	–22.73	–0.01

NOOTKA SOUND, VANCOUVER ISL'D.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1778.2	–19.75	–20.20	+0.45
1786.6	21.50	20.50	–1.00
1791.6	22.50	20.70	–1.80
1792.8	18.37	20.75	+2.38
1860.5	23.78	23.39	–0.39
1863.5	23.08	23.45	+0.37
1881.7	–23.60	–23.60	0.00

KAILUA, SANDWICH ISLANDS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1779.5	– 8.1	– 7.73	– .37
1791.8	8.03	8.39	+ .36
1793.3	7.78	8.45	+ .67
1796.1	8.73	8.58	– .15
1819.5	9.83	9.22	– .61
1824.5	10.23	9.26	– .97
1825.5	8.85	9.27	+ .42
1841.5	8.83	9.15	+ .32
1853.5	8.25	8.84	+ .59
1877.5	– 8.00	– 7.70	– .30

HONOLULU, SANDWICH ISLANDS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1792.2	– 7.83	– 8.80	+ .97
1796.1	9.68	9.05	– .63
1816.5	10.95	10.01	– .94
1819.5	10.40	10.10	– .30
1825.0	9.87	10.22	+ .35
1827.5	10.43	10.27	– .16
1836.5	10.18	10.33	+ .15
1837.5	10.33	10.33	.00
1838.5	10.05	10.32	– .33
1840.5	9.28	10.31	+1.03
1859.1	9.68	9.94	+ .26
1871.5	9.60	9.35	– .25
1872.5	9.30	9.30	.00
1875.5	– 9.26	– 9.12	– .14

SITKA, ALASKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1786.6	–26.77	–25.96	–0.81
1787.4	24.00	26.00	+2.00
1791.6	27.77	26.23	–1.54
1804.6	26.75	26.97	+0.22
1818.5	27.25	27.73	+0.48
1824.5	27.50	28.03	+0.53
1827.5	28.83	28.17	–0.66
1829.9	28.31	28.28	–0.03
1838.6	28.62	28.62	0.00
1842.6	28.54	28.75	+0.21
1843.5	28.90	28.77	–0.13
1844.5	28.96	28.80	–0.16
1845.5	29.00	28.83	–0.17
1847.7	28.98	28.89	–0.09
1848.5	29.08	28.90	–0.18
1849.1	29.06	28.92	–0.14
1850.5	28.84	28.95	+0.11
1851.5	28.88	28.97	+0.09
1852.4	28.81	28.98	+0.17
1856.5	28.98	29.04	+0.06
1857.5	29.12	29.06	–0.06
1858.5	29.18	29.07	–0.11
1859.5	29.10	29.08	–0.02
1860.5	29.13	29.08	–0.05
1861.5	29.07	29.09	+0.02
1862.5	29.02	29.09	+0.07
1863.5	29.06	29.10	+0.04
1864.5	29.07	29.10	+0.03
1867.6	28.82	29.10	+0.28
1874.3	28.99	29.05	+0.06
1876.1	–28.34	–29.02	+0.68

TABLE II—Continued.

SITKA, ALASKA—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1879.3	−28.90	−28.97	+0.07
1880.4	29.08	28.95	−0.13
1881.7	−29.19	−28.92	−0.27

PORT MULGRAVE, ALASKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1778.3	−23.80	−24.16	+ .36
1787.4	26.00	25.75	− .25
1791.5	26.67	26.45	− .22
1794.5	26.00	26.94	+ .94
1802.0	29.00	28.12	− .88
1823.5	30.50	30.74	+ .24
1874.4	29.97	30.32	+ .35
1880.5	−30.00	−29.65	− .35

PORT ETCHES, ALASKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1778.4	−23.62	−24.45	+ .83
1787.4	26.25	26.22	− .03
1790.5	26.47	26.80	+ .33
1794.5	28.50	27.53	− .97
1830.5	31.63	31.75	+ .12
1837.7	31.63	31.92	+ .29
1874.4	−29.16	−28.99	− .17

ST. PAUL, KADIAK, ALASKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1778.4	−22.10	−23.22	+1.12
1790.5	25.50	24.58	−0.92
1804.6	26.12	25.95	−0.17
1808.5	25.75	26.26	+0.51
1818.5	−26.50	26.90	+0.40

ST. PAUL, KADIAK, ALASKA—C'd.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1834.5	−28.63	−27.38	−1.25
1839.5	26.72	27.38	+0.66
1845.5	27.00	27.29	+0.29
1867.7	26.08	26.10	+0.02
1874.4	25.37	25.52	+0.15
1880.5	−25.15	−24.92	−0.23

UNALASHKA, ALASKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1790.4	−19.59	−19.04	− .55
1792.5	19.00	19.10	+ .10
1817.5	19.40	19.67	+ .27
1827.6	19.83	19.77	− .06
1831.5	19.50	19.79	+ .29
1849.5	20.00	19.69	− .31
1867.7	−19.79	−19.33	− .46

UNALASHKA, ALASKA—Cont'd.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1870.5	−19.75	−19.26	− .49
1873.5	19.06	19.17	+ .11
1874.7	18.71	19.13	+ .42
1880.6	−18.63	−18.95	+ .32

PETROPAVLOVSK, KAMTCHATKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1779.5	− 6.31	− 6.27	− .04
1792.5	6.00	5.98	− .02
1804.7	5.49	5.51	+ .02
1827.6	4.07	4.21	+ .14
1837.7	3.45	3.54	+ .09
1849.5	2.62	2.75	+ .13
1854.5	3.67	2.43	−1.24
1866.5	1.42	1.70	+ .28
1876.6	− 1.15	− 1.18	+ .03

TABLE II (*b*).—COMPARISON OF OBSERVED AND COMPUTED DECLINATIONS.

ST. JOHN'S, NEWFOUNDLAND.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1844.8	+29.60	+29.70	− .10
1857.5	31.35	30.98	+ .37
1862.7	31.33	31.20	+ .13
1863.7	31.30	31.22	+ .08
1864.4	31.00	31.23	− .23
1866.5	30.92	31.25	− .33
1881.7	+30.62	+30.53	+ .09

CHARLOTTE TOWN, PRINCE EDWARD ISLAND.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1842.4	+21.05	+21.09	− .04
1857.4	23.03	22.77	+ .26
1858.4	22.90	22.85	+ .05
1859.4	22.85	22.93	− .08
1860.4	22.83	22.99	− .16
1861.4	22.75	23.05	− .30
1862.4	+23.32	+23.10	+ .22

TYRONE, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1871.6	+ 3.15	+ 3.25	− .10
1873.4	3.35	3.34	+ .01
1874.4	3.33	3.40	− .07
1875.4	3.43	3.46	− .03
1878.9	3.70	3.65	+ .05
1879.2	+ 3.80	+ 3.67	+ .13

PITTSBURG, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1840.7	+ 0.13	+ 0.13	....
1845.3	+ 0.55	+ 0.55	....
1878.7	+ 2.36	+ 2.36	....

CHICAGO, ILL.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1823.5	− 6.20	− 6.20	....
1857.6	− 5.77	− 5.77	....
1878.7	− 4.55	− 4.55	....

GRAND HAVEN, MICH.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1825.5	− 5.25	− 5.16	− .09
1837.5	5.08	5.24	+ .16
1859.6	4.40	4.47	+ .07
1865.5	4.25	4.07	− .18
1873.7	3.47	3.38	− .09
1880.5	− 2.43	− 2.68	+ .25

MADISON, WIS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1878.8	− 6.52	− 6.53	+ .01
1879.7	6.48	6.47	− .01
1880.7	6.37	6.40	+ .03
1881.9	− 6.33	− 6.33	.00

MICHIPICOTEN, ONTARIO, CANADA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1824.5	− 4.55	− 4.55	....
1844.5	− 3.82	− 3.82	....
1880.6	+ 1.34	+ 1.34	....

DULUTH, MINN., AND SUPERIOR CITY, WIS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1871.1	−10.58	−10.58	....
1880.6	− 9.76	− 9.76	....

ST. GEORGE'S TOWN, BERMUDA ISLANDS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1831.5	+ 6.98	+ 6.89	+ .09
1837.5	6.67	6.86	− .19
1845.8	7.02	6.90	+ .12
1846.5	6.88	6.91	− .03
1876.5	+ 7.75	+ 7.76	− .01

RIO JANEIRO, BRAZIL.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1768.5	− 7.57	− 7.47	− .10
1787.5	6.20	6.31	+ .11
1820.5	2.90	3.26	+ .36
1821.5	3.35	3.25	− .10
1830.4	2.14	2.23	+ .09
1836.5	− 2.00	− 1.50	− .50
1857.5	+ 1.33	+ 1.36	− .03
1866.0	+ 2.70	+ 2.65	+ .05
1876.5	+ 4.43	+ 4.36	+ .07

SAN ANTONIO, TEX.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1825.5	−10.50	−10.50	.00
1836.5	9.75	10.38	+ .63
1874.5	9.50	9.50	.00
1878.4	− 9.37	− 9.37	.00

OMAHA, NEBR. AND COUNCIL BLUFFS, IOWA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1819.7	−12.98	−12.99	+ .01
1869.1	10.71	10.82	+ .11
1872.8	10.74	10.66	− .08
1877.8	10.37	10.44	+ .07
1878.7	10.66	10.40	− .26
1880.8	−10.10	−10.31	+ .21

DENVER, COLO.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
	°	°	°
1866.5	−15.00	−14.96	− .04
1872.8	14.75	14.79	+ .04
1873.6	14.71	14.77	+ .06
1878.6	−14.70	−14.64	− .06

SALT LAKE CITY, UTAH.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1850.5	−15.57	−15.56	− .01
1866.6	16.50	16.55	+ .05
1869.4	16.61	16.63	+ .02
1872.5	17.01	16.69	− .32
1878.7	16.77	16.70	− .07
1881.4	−16.47	−16.65	+ .18

PORT TOWNSHEND, WASH. TER.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1841.5	−20.67	−20.61	− .06
1856.6	21.66	21.77	+ .11
1857.5	21.77	21.81	+ .04
1862.5	22.00	21.96	− .04
1876.1	21.98	21.87	− .11
1881.9	−21.45	−21.58	+ .13

PORT CLARENCE, ALASKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1827.5	−26.92	−26.93	+ .01
1850.5	26.43	26.36	− .07
1854.5	26.00	26.07	+ .07
1879.5	23.02	22.90	− .12
1880.7	−22.75	−22.75	.00

CHAMISSO ISLAND, ALASKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O – C.
1826.5	−30.49	−30.49	....
1849.5	−30.43	−30.43	....
1880.7	−26.82	−26.82	....

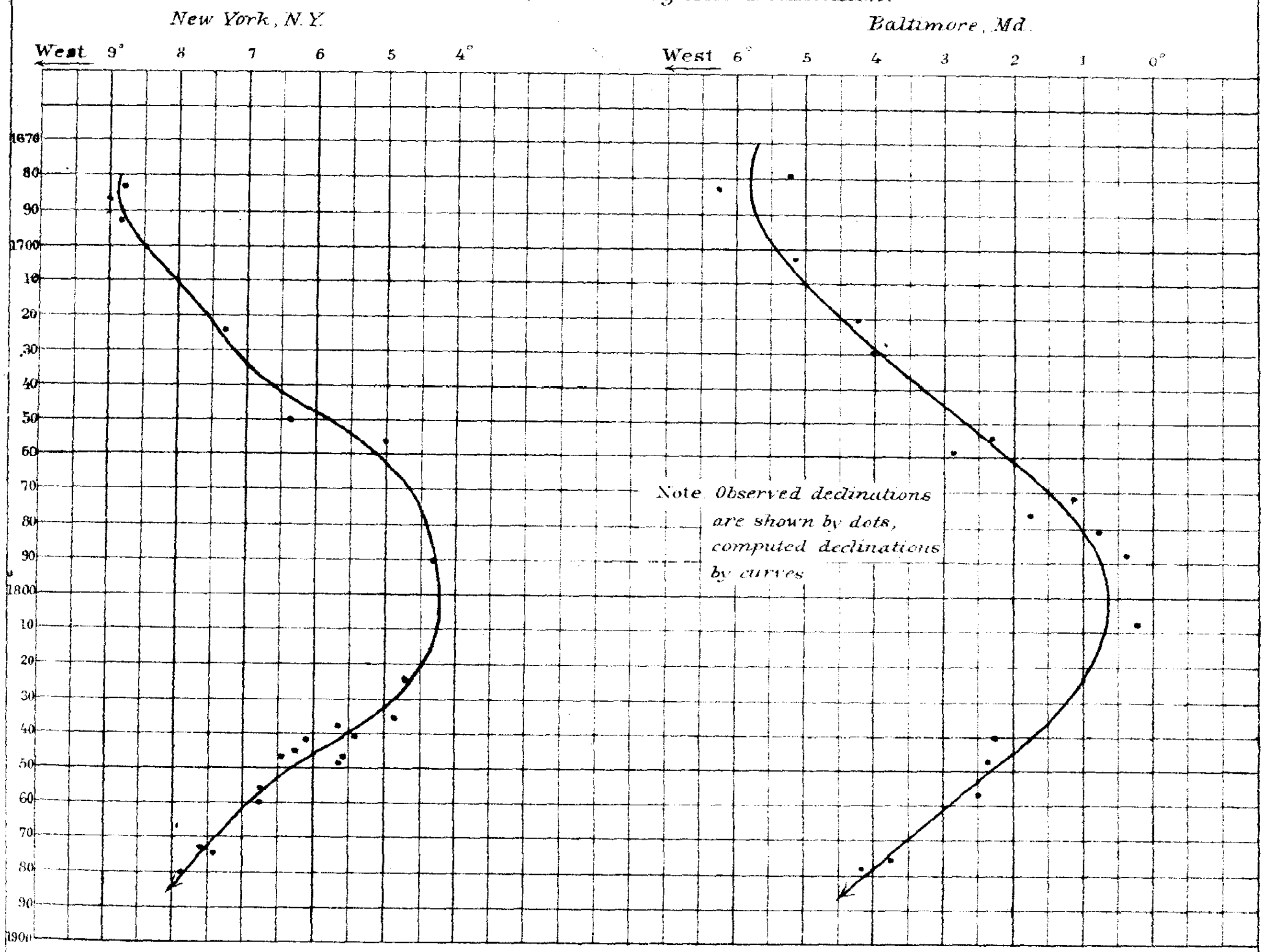
To facilitate the comparison of the results at widely different localities there has been added to this paper a plate, No. 33, headed "Secular variation of the magnetic declination." It exhibits the observed and computed declinations for New York, Baltimore, San Francisco and Sitka. On plate No. 36, Paris, France and on plate No. 33, New York and Baltimore have been introduced for the special purpose of showing in a conspicuous manner the great regularity of the secular motion, and thus impressing the mind with the fact that the explanation of the secular change must ultimately be referred to forces of a periodic character acting, for centuries, with great regularity and over vast areas. So far no approach has yet been made towards the discovery of the cause of this variation. The diagrams also assist in connecting the phases of the secular variation as exhibited for places in the United States with the corresponding phases of the motion in Western Europe and Eastern Asia.

The following Table III shows for each station: (1) the number of observations used in the discussion of the secular variation; (2) the apparent probable error, in minutes of arc, of one observation (including all sources of error, namely, those caused by imperfect value of the average declination due to diurnal variation and disturbances of the needle, those caused by difference of location of station, those arising from purely instrumental defects and those due to imperfection of formula); (3) the computed epoch of greatest easterly deflection reached in the secular motion, *i. e.*, the date when last reached or the date (in parentheses) when it is next expected to be in that position; (4) the amount, in degrees and fractions, and direction (+ west, − east) at this the nearest stationary epoch; (5) (6) and (7) the computed annual changes for the epochs 1870, 1880 and 1885, expressed in minutes of arc, a + sign indicating north end of needle moving westward, a − sign north end moving eastward. Table III (*b*) contains similar information for the secondary stations.

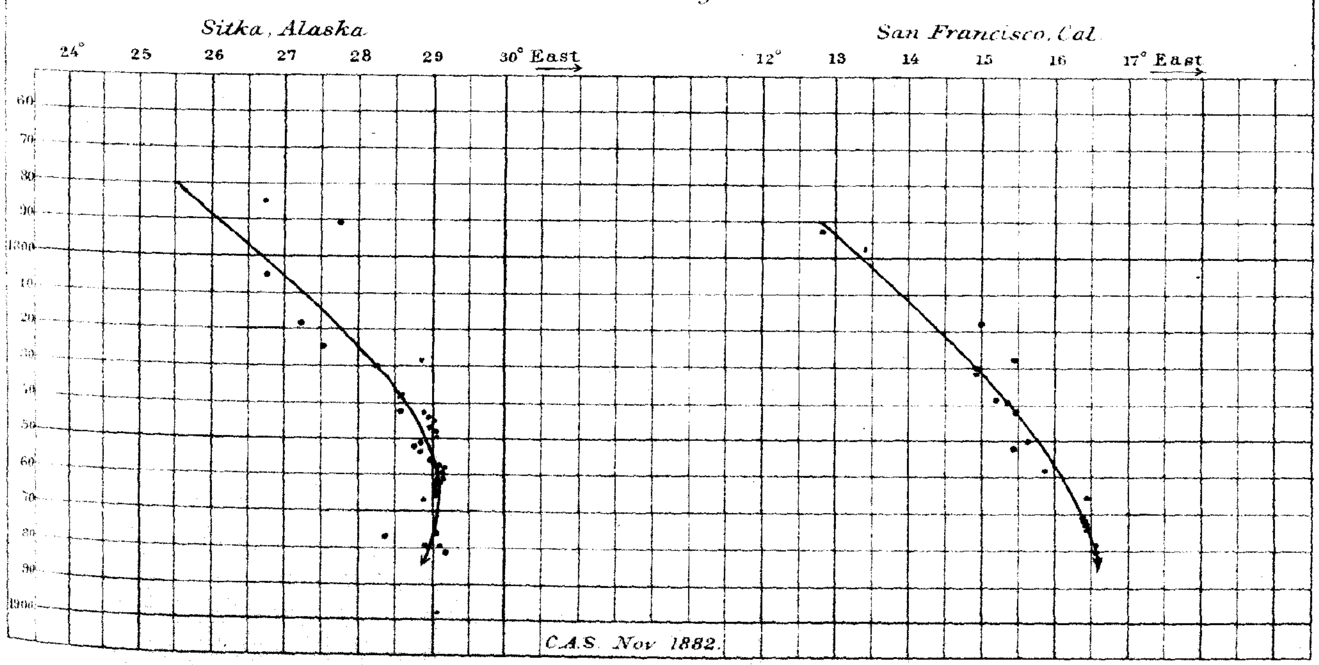
TABLE III.—ANNUAL CHANGE OF THE DECLINATION AND OTHER DATA.

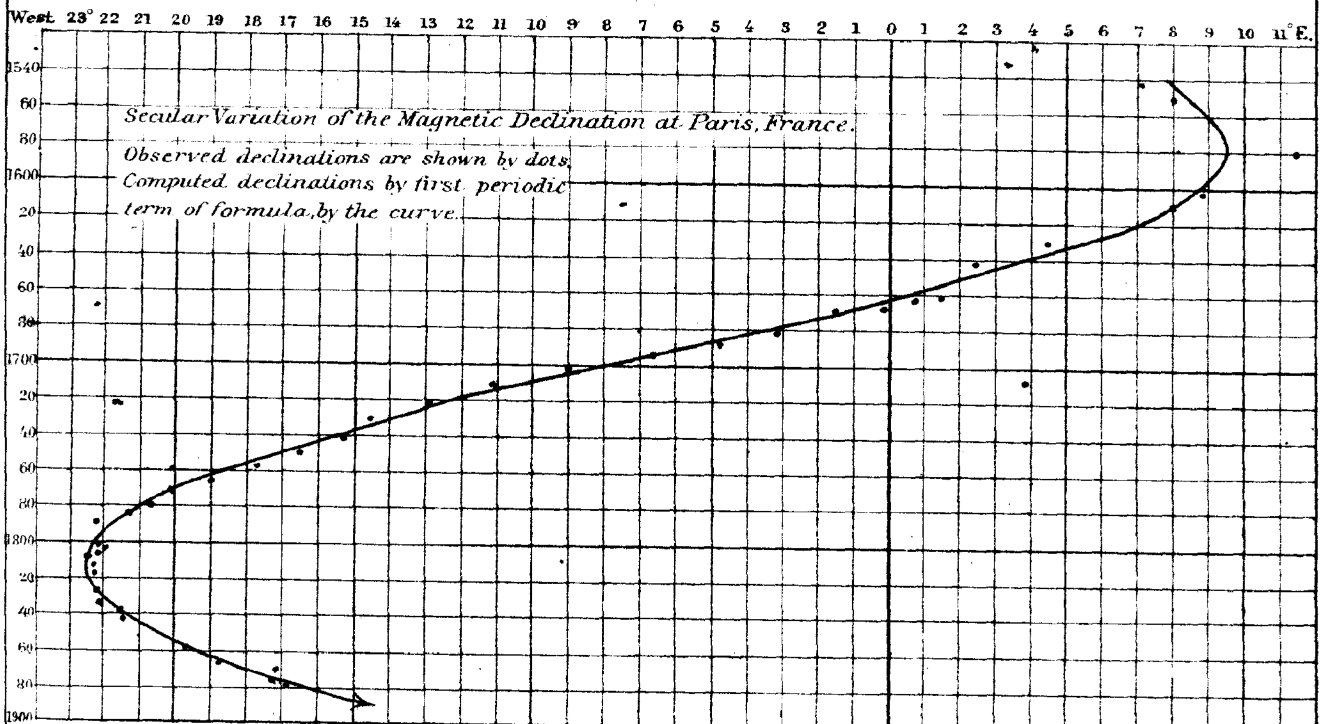
Locality.	Number of observations.	Apparent probable error of an observation.	Nearest stationary epoch of easterly digression.	Amount at easterly digression.	Annual change. In 1870.	In 1880.	In 1885.
		′		°	′	′	′
Paris, France*	41	±17	1581	−10.6	− 7.0	− 6.1	− 9.5
Halifax, Nova Scotia	11	30	1728	+12.4	+ 1.8	+ 1.0	+ 0.5
Quebec, Canada	37	20	1809	+12.1	+ 4.2	+ 1.6	+ 0.5
Montreal, Canada	9	30	1816	+ 7.6	+ 5.1	+ 3.1	+ 2.8
York Factory, Hudson Bay	6	41	1850	− 9.2	+ 9.4	+13.6	+15.4
Eastport, Me	9	± 4	1760	+12.5	+ 3.3	+ 2.7	+ 2.3
Portland, Me	10	9	1764	+ 8.0	+ 2.4	+ 1.6	+ 1.2
Burlington, Vt	13	13	1810	+ 7.2	+ 5.0	+ 6.0	+ 5.8
Rutland, Vt.	6	16	1806	+ 6.2	+ 6.0	+ 5.6	+ 5.3
Portsmouth, N. H	6	6	1791	+ 7.5	+ 4.4	+ 3.7	+ 3.3
Newburyport, Mass	4	±13	1784	+ 7.0	+ 3.9	+ 3.3	+ 2.9
Salem, Mass	6	33	1791	+ 6.2	+ 5.0	+ 4.1	+ 3.5
Boston, Mass	12	24	1777	+ 6.6	+ 3.4	+ 2.9	+ 2.5
Cambridge, Mass	24	11	1783	+ 6.9	+ 2.9	+ 2.1	+ 1.8
Nantucket, Mass	9	7	1779	+ 6.5	+ 3.3	+ 2.7	+ 2.4
Providence, R. I	10	± 7	1780	+ 6.1	+ 3.8	....	....
Hartford, Conn	7	12	1799	+ 5.2	+ 3.8	+ 3.7	+ 3.6
New Haven, Conn	16	11	1802	+ 4.7	+ 4.6	+ 4.3	+ 4.1
Albany, N. Y	13	6	1793	+ 5.2	+ 4.3	+ 3.7	+ 3.4
Oxford, N. Y	13	9	1797	+ 3.0	+ 4.5	+ 4.3	+ 4.0
Buffalo, N. Y	8	±10	1806	+ 0.2	+ 5.1	+ 5.0	+ 4.8
Toronto, Canada	38	2	....	....	+ 4.8	+ 4.5	+ [illegible].3
Erie, Pa	10	13	1811	− 0.5	+ 4.4	+ 4.2	+ 4.0
Marietta, Ohio	7	23	1815	− 2.9	+ 4.2	+ 4.2	+ [illegible]
Cleveland, Ohio	13	13	1790	− 2.0	+ 2.8	+ 2.5	+ [illegible]

Secular Variation of the Magnetic Declination.



Secular Variation of the Magnetic Declination.





U. S. Coast and Geodetic Survey
October 1882.

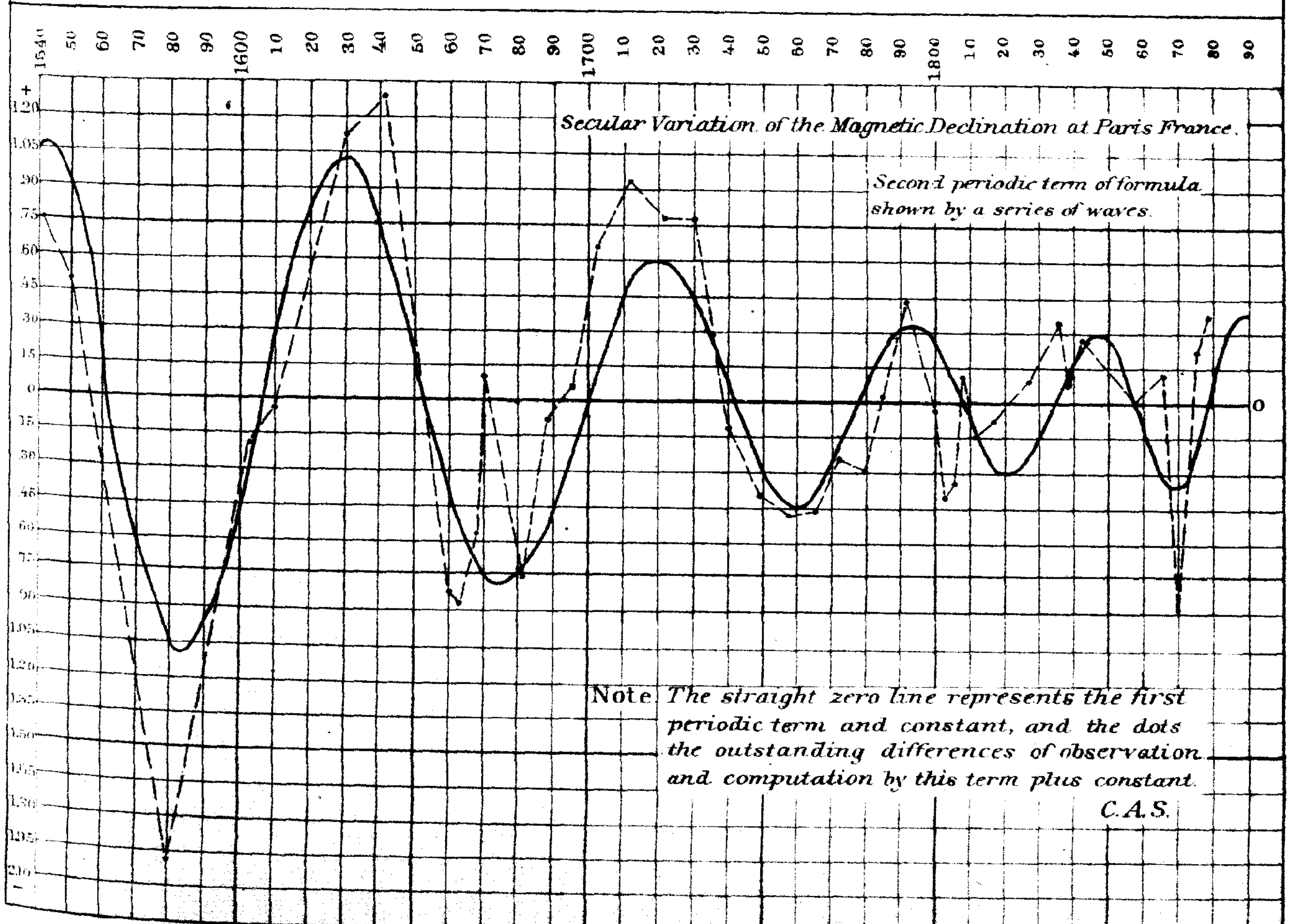


TABLE III—Continued.

Locality.	Number of observations.	Apparent probable error of an observation.	Nearest stationary epoch of easterly digression.	Amount at easterly digression.	Annual change. In 1870.	Annual change. In 1880.	Annual change. In 1885.
		′		°	′	′	′
Detroit, Mich	10	±10	1800	−3.2	+3.4	+3.0	+2.8
Sault de Ste. Marie, Mich	8	9	1828	−1.2	+3.6	+4.0	+4.1
Cincinnati, Ohio	5	10	1815	−5.0	+3.8	+3.9	+3.8
Saint Louis, Mo	7	23	1800	−9.5	+3.4	+3.2	+3.0
New York, N. Y	21	15	1797	+4.0	+2.4	+2.5	+2.6
Hatborough, Pa	18(?)	±6	1797	+1.8	+4.6	+4.5	....
Philadelphia, Pa	15	14	1800	+1.9	+4.9	+4.9	+5.3
Harrisburg, Pa	10	15	1790	0.0	+4.1	+3.3	+2.8
Baltimore, Md	17	17	1802	+0.6	+3.9	+3.6	+3.2
Washington, D. C	26	8	1796	0.0	+3.5	+3.2	+3.0
Cape Henry, Va	6	±11	1814	+0.1	+3.8	+3.7	+3.6
Charleston, S. C	11	23	1784*	−4.9	+3.5	+3.0	+2.7
Savannah, Ga	5	15	1809	−4.9	+3.6	+3.5	+3.3
Key West, Fla	11	3	1810	−6.8	+4.3	+4.2	+4.1
Havana, Cuba	7	26	1801	−6.5	+2.7	+2.7	+2.6
Kingston, Jamaica	11	±21	1762	−6.7	+2.0	+1.6	+1.4
Panama, New Granada	9	24	1739	−8.6	+1.5	+1.4	+1.3
Florence, Ala	5	7	1821	−6.6	+2.8	+3.1	+3.2
Mobile, Ala	7	4	1841	−7.1	+2.8	+3.4	+3.7
New Orleans, La	10	20	1830	−8.2	+3.1	+3.5	+3.7
Vera Cruz, Mexico	9	±25	1827	−9.4	+4.2	+4.9	+5.2
Mexico, Mexico	12	10	1839	−8.8	+2.4	+3.0	+3.3
Acapulco, Mexico	8	21	1841	−9.0	+2.4	+3.2	+3.5
San Blas, Mexico	8	6	1868	−9.3	+0.1	+0.5	+0.7
Magdalena Bay, Lower Cal	6	21	(1890)	−10.8	−1.8	−1.0	−0.5
San Diego, Cal	7	±5	(1925)	−14.1	−1.8	−1.6	−1.5
Monterey, Cal	11	19	(1903)	−16.2	−1.8	−1.3	−1.0
San Francisco, Cal	19	8	(1890)	−16.6	−1.0	−0.5	−0.3
Cape Disappointment, Wash. Ter	8	12	(1922)	−22.6	−2.8	−2.5	−2.2
Nee-ah Bay, Wash. Ter	5	36	(1890)	−22.8	−1.4	−0.7	−0.4
Nootka Sound, Vancouver Island	7	±32	1880	−23.6	−0.7	0.0	+0.3
Kailua, Sandwich Islands	10	25	1828	−9.3	+3.1	+3.7	+3.9
Honolulu, Sandwich Islands	14	24	1836	−10.3	+3.1	+3.9	+4.2
Sitka, Alaska	34	18	1865	−29.1	+0.4	+1.2	+1.6
Port Mulgrave, Alaska	8	28	1847	−31.8	+5.3	+7.2	+8.1
Port Etches, Alaska	7	±26	1839	−31.9	+8.3	+10.2	+10.9
Saint Paul, Kadiak, Alaska	11	29	1837	−27.4	+5.1	+6.1	+6.5
Unalashka, Alaska	11	16	1834	−19.8	+1.6	+1.9	+2.0
Petropavlovsk, Kamtchatka	9	16	1771	−6.3	+3.2	+2.5	+2.2

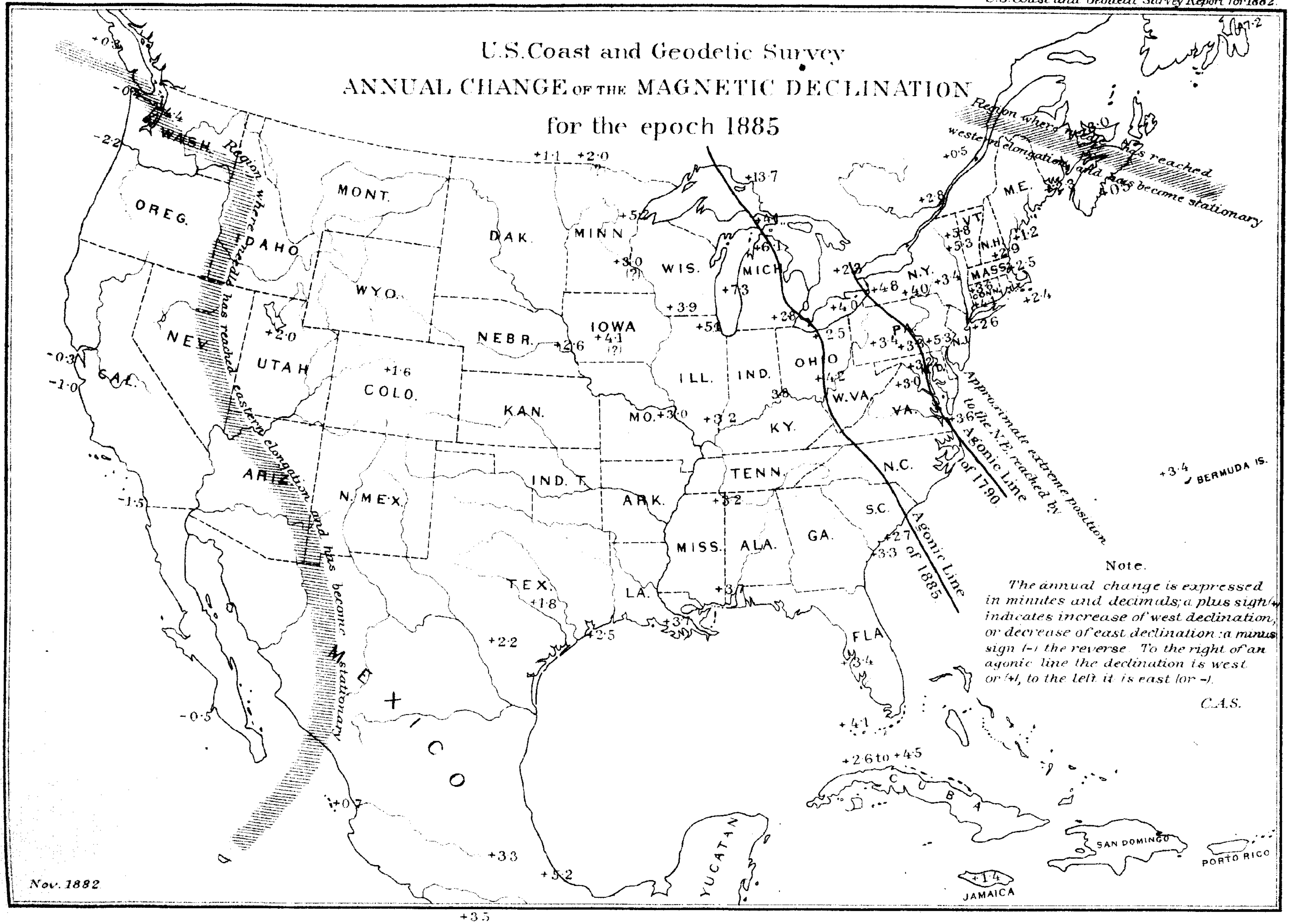
* The maximum or westerly digression was reached, according to observations, in 1814, amount +22°.5 nearly; hence, range between extremes, 33°.1 and apparent half period, 233 years. The formulæ suppose length of principal period = 470.6 years. The annual change is that given by $D_{,,}$.

TABLE III (*b*).

Locality.	Number of observations.	Nearest stationary epoch of easterly digression.	Amount at easterly digression.	Nearest stationary epoch of westerly digression.	Amount at westerly digression.	Annual change. In 1880.	Annual change. In 1885.
			°		°	′	′
St. John's, Newfoundland	7	....	....	1867	+31.3	− 5.2	− 7.2
Charlotte Town, Prince Edward Island	7	....	....	1874	+23.5	− 1.6	− 3.0
Tyrone, Pa	6	....	....	....	....	+ 3.3	....
Pittsburg, Pa	3	....	....	....	....	+ 3.4	....
Chicago, Ill	3	1833	− 6.3	....	....	+ 4.6	+ 5.1
Grand Haven, Mich	6	1834	− 5.3	....	....	+ 6.6	+ 7.3
Madison, Wis	4	....	....	....	....	+ 3.9	....
Michipicoten, Ontario, Can	3	1825	− 4.6	....	....	+12.6	+13.7
Duluth, Minn., and Superior City, Wis	3	....	....	....	....	+ 5.2	....
St. George's Town, Bermuda Islands	5	1838	+ 6.8	....	....	+ 3.0	+ 3.4
Rio Janeiro, Brazil	9	....	....	....	....	+10.3	+10.7
San Antonio, Tex	3	....	....	....	....	+ 2.1	+ 2.2
Omaha, Nebr. and Council Bluffs, Iowa	5	....	....	....	....	+ 2.6	....
Denver, Col	4	....	....	....	....	+ 1.6	....
Salt Lake City, Utah	6	1876	−16.7	....	....	+ 0.9	+ 2.0
Port Townshend, Wash	6	1868	−22.0	....	....	+ 3.1	+ 4.4
Port Clarence, Alaska	4	1852	−27.0	....	....	+10.3	+11.3
Chamisso Island, Alaska	3	1837	−30.7	....	....	+10.7	+12.0

The actual number of observations at Hatborough, Pa., is unknown and probably is less than one-third of the values used in the discussion. The probable errors given will serve to convey some idea of the relative value of each series of observations. The imperfections in the instrumental means and methods of the older observations in many cases react unfavorably on the modern observations, which are made with more precise instruments and by more refined methods. If we take, for instance, the observations of Hudson, made in 1609, in the vicinity of New York, we find each fairly chargeable with a probable error of about ± 4°. While these observations are very imperfect, those of Champlain of about the same period (1604 to 1612) are still cruder. These two navigators differ nearly 9° at the mouth of the Penobscot, Maine and double this amount at Cape Cod. The observations made by Vancouver on our western coast, between 1792 and 1794, are subject to a probable uncertainty of ± 1° (each), and even now it requires favorable circumstances to determine the variation of the compass at sea with a probable error of half a degree or to make sure of the nearest whole degree. Increased precision was attained with the improvement of the azimuth compass and by allowance for disturbing effect of the ship's iron, and, with respect to shore stations, greater accuracy was obtained by the introduction of the theodolite for determining the astronomical meridian. With a portable magnetometer and a collimator magnet, the instrumental means need not introduce a greater uncertainty than about one minute; but the actual probable error of any determination is dependent also on the accidental variations in the mean direction of the magnetic force from day to day, thus making it desirable and indispensable for precise work to continue the observations for three or more days and to correct the results for diurnal variation. The amount of the probable error of the observed declination depends also on the intensity of the horizontal component of the magnetic force at the place, *i. e.*, in general the smaller the horizontal force the larger the apparent probable error.

To facilitate the use of the deduced annual change for the purpose of bringing results up to date, and in order that a more comprehensive general view of its distribution in sign and amount may be had, the values of the last column of Tables III and III (*b*) were laid down on the accompanying chart (Plate No. 34) bearing the title "Annual change of the magnetic declination." It


U.S. Coast and Geodetic Survey
ANNUAL CHANGE OF THE MAGNETIC DECLINATION
for the epoch 1885
Region where needle has reached western elongation and has become stationary
Region where needle has reached eastern elongation and has become stationary
Approximate extreme position to the N.E. reached by Agonic Line of 1790
Agonic Line of 1885
Note.
The annual change is expressed in minutes and decimals; a plus sign (+) indicates increase of west declination, or decrease of east declination; a minus sign (−) the reverse. To the right of an agonic line the declination is west or (+), to the left it is east (or −).
C.A.S.
Nov. 1882
WASH.
OREG.
CAL.
IDAHO
NEV.
UTAH
ARIZ.
MONT.
WYO.
COLO.
N. MEX.
DAK.
NEBR.
KAN.
IND. T.
TEX.
MINN.
IOWA
MO.
ARK.
LA.
WIS.
ILL.
MICH.
IND.
OHIO
KY.
TENN.
MISS.
ALA.
GA.
FLA.
S.C.
N.C.
VA.
W.VA.
PA.
N.Y.
VT.
N.H.
MASS.
CONN.
N.J.
D.
M.E.
MEXICO
YUCATAN
CUBA
JAMAICA
SAN DOMINGO
PORTO RICO
BERMUDA IS.
+13.7
+1.1
+2.0
+2.6
+4.1
+3.0
+3.9
+7.3
+2.8
+3.2
+2.5
+4.8
+4.0
+3.4
+5.3
+2.9
+1.2
+2.4
+2.6
+3.6
+2.7
+3.3
+3.7
+1.8
+2.2
+1.6
+2.0
+0.5
−2.2
−0.3
−1.0
−1.5
−0.5
+0.7
+3.3
+5.2
+3.5
+4.1
+3.4
+2.6 to +4.5
+1.4
+7.2

will be seen that the annual change has the *positive* sign for by far the greater part of the United States, but in a region about Newfoundland and the Gulf of St. Lawrence, in the extreme northeast, and in a region including parts of Washington Territory, Idaho, Nevada, Arizona and Mexico, and passing into the Pacific south of Lower California in the extreme southwest, we meet with two smaller areas of *negative* sign.

The boundaries between these two areas of negative annual change with the intermediate area of positive annual change form two broad belts where the needle is at present in a stationary condition. The outlines of these belts cannot now be exactly defined, nor has it been found, as yet, practicable to construct a system of curves of *equal annual change* (such as was attempted for a limited area in Coast Survey Report for 1865, plate No. 28). The maximum amount of annual change, as charted and within the United States, appears to be in Vermont and Michigan; it is, however, surpassed in the Territory of Alaska, where the annual change is likewise positive. The present motion of the isogonic curves is southward along our Atlantic and Pacific seaboards, but slowly north-easterly in the greater part of Alaska; an intermediate region of no annual change passing through the Strait of Fuca. On the chart there are also presented two agonic lines (or lines of zero declination, the magnetic needle pointing due north), one for the epoch of 1790, when it and the corresponding system of isogonic lines in its neighborhood had reached nearly their extreme positions to the northeast; the other for the epoch 1885; the space between them showing the shifting to the southwest of the first-named agonic line during the last 95 years. The agonic line is now in rapid motion to the south and west, carrying with it the corresponding system of other isogonic lines in its vicinity.

A cursory examination of column 4 of Table III and column 3 of Table III (*b*) containing the epoch of the greatest *easterly* digression, at which time the deflecting force producing the secular change had an easterly maximum, shows that in Western Europe (Paris) this phase of the secular motion occurred about 1581; but near the coast of the New England States the needle became stationary in direction and then reversed its previous angular motion at a very much later epoch, viz, about 1760 to 1780. Going westward or southward, this epoch was observed later, about 1800, in Illinois and Missouri, and about 1810 in Florida. It occurred as late as 1830 (about) in Mississippi, and in 1839 (about) in the city of Mexico, and at San Blas, Mex., about 1868. The needle has not yet reached this state in Lower California and along our western coast as far north as the Strait of Fuca. This stationary condition may be expected in our western coast States south of the Columbia River toward the close of the present or early in the next century. At Sitka the maximum east declination occurred in 1865, and farther to the westward and northward, in the vicinity of the Kenay Peninsula, about 20 years earlier.

We are thus directed to look to the extreme northeastern limit of the United States for probable indications of the magnetic change, which may be expected to follow and spread from the eastern boundary of Maine westward and southward, and we may also expect that the area of western coast States and Territories now having still slowly increasing easterly declination will, after the lapse of about a quarter of a century, change into an area of slow decrease; in other words, the belt of present stationary needle will have moved westward and reached the Pacific. Respecting this secular variation the phases of the phenomenon to the northeast of Maine and in the region including Arizona, Nevada, and Idaho, are almost in opposition. At the time when the needle took up its *westerly* motion in our Northeastern States in the last quarter of the past century, it had probably not for a very long time acquired its *easterly* motion in the States of the western coast. At present, in Nova Scotia, the motion appears to be approaching its westerly extreme whereas in California it is tending toward its easterly extreme.

If we fix now for a moment our attention to the *western* extreme of stationary condition, which happened at Paris about 1814, or 68 years ago, we find that at Saint John's, Newfoundland, the needle had arrived at this phase about 1867, and at Halifax, Nova Scotia, we are led to expect it to occur shortly (about 1891). In the State of Maine, and farther on to the west and south, this phase is expected to occur some time early in the next century. We thus trace the progressive motion of the secular change from eastern to western countries, and if we were to compare it with a wave motion, the present stationary conditions in the northeast and in the west, or Rocky

Mountain region, would correspond to opposite phases, one a crest, the other a trough, with the space between representing half a wave length.

Supposing the needle deflected by the horizontal component of an electric current traversing the earth's crust, the secular variation could be explained by a swaying motion in the direction of the current, the needle always tending to place itself at right angles thereto. The deflecting forces are maxima over the two regions where the annual change in the direction of the needle has vanished.

Looking over the numerical values of α in Table I, they would imply for stations in the United States a secular variation cycle varying between the limits of about 220 and 360 years; numbers which are necessarily yet very uncertain.

On plate No. 35 appended to this paper I have delineated the secularchange of the agonic line of the North Atlantic, to illustrate the effect of the corresponding change in the declination in a manner quite different from that referring to tabular numbers. It shows the positions of this agonic line for the epochs 1500, 1600, 1700, 1800, also for 1880 and 1900. The earliest position is more or less conjectural and rests on the authority of Columbus for its place near the Middle Atlantic; we also know that it must have passed over a region near Paris, France, and not far from a space including the Antilles. The position for 1600 is taken from Hansteen's work (1819), and may be considered as a rough approximation; it has been corrected by me near its western end. The position for 1700 is more reliable, since it depends on numerous observations collected by Halley; it is directly taken from his chart. The positions for 1800 and 1880 require no further explanation. The position for 1900, though prospective, is quite certain. Upon the whole, the azimuthal motion of the isogonic system in the vicinity of the agonic line of the North Atlantic, and as represented by this line, has been, since 1600, in the direction of the hands of a watch.

TABLES OF DECENNIAL VALUES OF THE MAGNETIC DECLINATION COMPUTED FROM PRECEDING EQUATIONS.

Tables IV and IV (*b*) have been constructed for the purpose of facilitating the reduction of observed declinations from one epoch to another, and for supplying the charts of the Coast and Geodetic Survey with the latest computed declinations. These values will be found especially useful when old lines, originally run by compass needle, have to be retraced at a later date; besides they are useful, when put in a more extended form, in the construction of isogonic charts for given epochs.

For the declination two places of decimals are given for all localities and dates for which the observations were considered reliable; one place of decimals indicates a less satisfactory result, and blanks indicate that no trustworthy results, or no results at all, could be had. The table should *not be extended* either by interpolation or by extrapolation beyond its given limits, except when supported by further evidence or new observations. The declinations are given in degrees and decimals, a + sign indicating west and a − sign east declination. The epoch is the first day of the given year.

No. 35

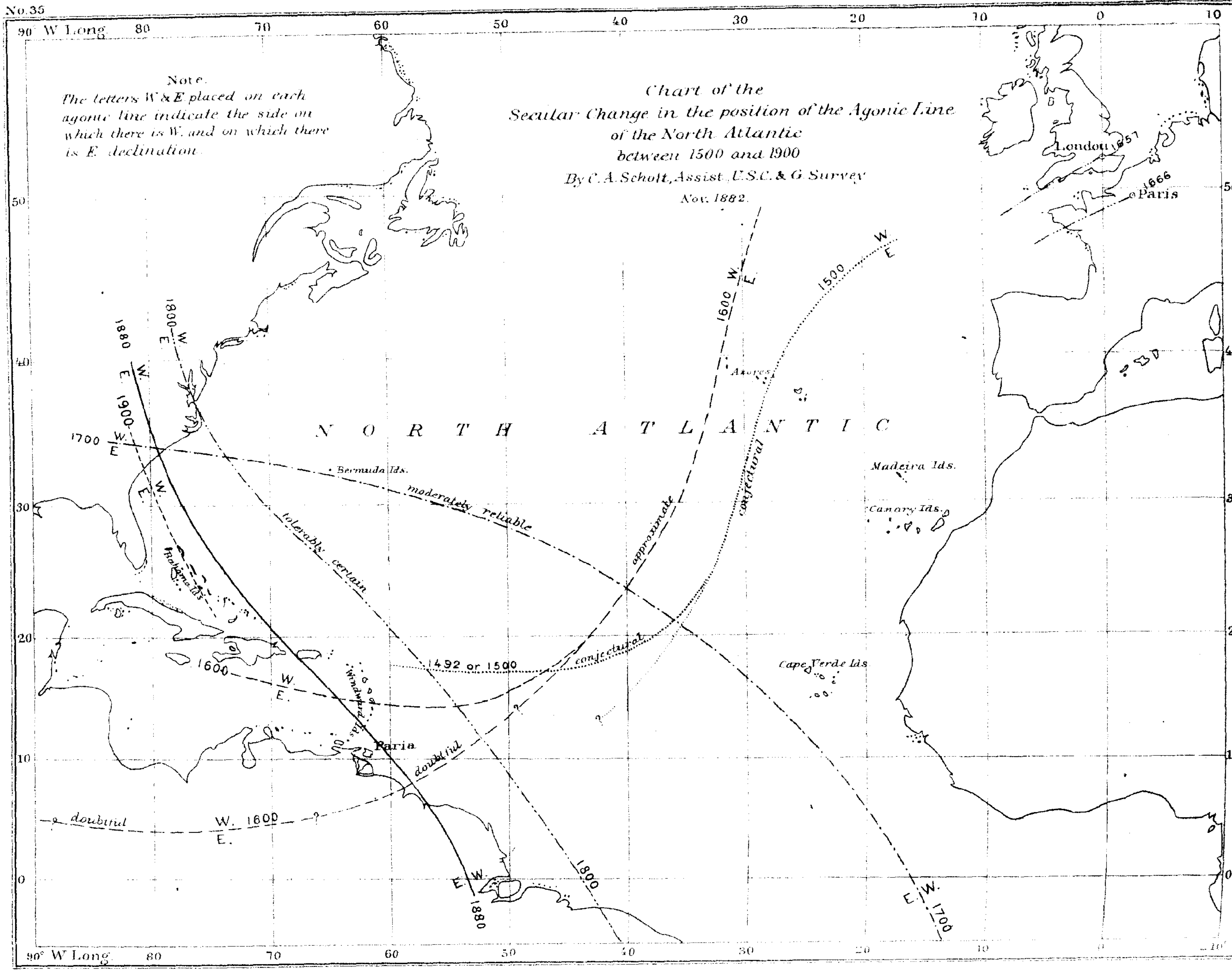


Chart of the
Secular Change in the position of the Agonic Line
of the North Atlantic
between 1500 and 1900
By C. A. Schott, Assist. U.S.C. & G. Survey
Nov. 1882.
Note.
The letters W & E placed on each agonic line indicate the side on which there is W. and on which there is E. declination.
NORTH ATLANTIC
London
Paris
1657
1666
Azores
Bermuda Ids.
Madeira Ids.
Canary Ids.
Cape Verde Ids.
Bahama Ids.
Windward Ids.
Paria
1500
1600
1700
1800
1880
1900
1492 or 1500
moderately reliable
tolerably certain
approximate
conjectural
doubtful
90° W Long.

TABLE IV.—DECENNIAL VALUES OF THE MAGNETIC DECLINATION.

Year.	Paris, France.	Halifax, N. S.	Quebec, Canada.	Montreal, Canada.	York Factory, Hudson Bay.	Eastport, Me.	Portland, Me.	Burlington, Vt.	Rutland, Vt.	Portsmouth, N. H.	Newburyport, Mass.	Salem, Mass.	Boston, Mass.	Cambridge, Mass.	Nantucket, Mass.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1540	− 6.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...
50	7.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...
60	8.9	...	...	...	...	...	...	...	...	...	...	...	...	...	...
70	10.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...
80	10.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...
90	−10.3	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1600	− 9.2	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	7.7	...	...	...	...	...	...	...	...	...	...	...	...	...	...
20	6.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	4.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...
40	3.5	...	+16.2	...	...	...	...	...	...	...	...	...	...	...	...
50	2.3	...	...	...	...	...	...	...	...	...	...	...	...	...	...
60	− 0.9	...	...	...	...	...	...	...	...	...	...	...	...	...	...
70	+ 0.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...
80	+ 2.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...
90	+ 5.2	...	+17.6	...	...	...	...	...	...	...	...	...	...	...	...
1700	+ 7.6	+13.0	+17.1	...	...	...	...	...	...	...	...	...	+10.0	+ 9.8	...
10	10.2	12.6	+16.1	...	...	...	...	...	...	...	...	...	9.4	9.2	...
20	12.5	12.5	...	...	+19.1	...	...	...	...	...	...	...	8.7	8.7	...
30	14.2	12.4	...	...	18.9	...	...	...	...	...	...	...	8.1	8.3	...
40	15.7	12.5	...	+11.9	17.8	...	...	...	...	...	...	...	7.6	7.9	...
50	17.1	12.8	...	10.5	15.9	...	...	...	...	...	...	...	7.1	7.5	...
60	18.3	13.2	...	9.5	13.5	...	+ 8.1	...	...	...	...	...	6.8	7.2	...
70	19.8	13.7	+12.5	8.9	10.5	+12.6	8.1	...	...	+ 7.9	+ 7.2	...	6.6	7.0	+ 6.6
80	21.1	14.3	12.44	8.7	7.2	12.8	8.2	...	+ 7.1	7.6	7.0	+ 6.3	6.6	6.9	6.5
90	+22.1	+15.0	+12.33	+ 8.4	+ 3.7	+13.2	+ 8.5	+ 7.4	+ 6.6	+ 7.5	+ 7.0	+ 6.2	+ 6.72	+ 6.9	+ 6.6
1800	+22.5	+15.8	+12.15	+ 8.0	+ 0.3	+13.7	+ 8.9	+ 7.3	+ 6.3	+ 7.6	+ 7.2	+ 6.3	+ 6.98	+ 7.1	+ 6.8
10	22.4	16.5	12.06	7.7	− 2.8	14.3	9.4	7.23	6.23	7.8	7.6	6.6	7.38	7.5	7.2
20	22.1	17.3	12.23	7.7	5.4	14.9	10.0	7.49	6.46	8.3	8.1	7.2	7.88	8.0	7.69
30	21.8	18.1	12.78	8.2	7.4	15.7	10.6	8.14	6.93	8.88	8.7	7.9	8.47	8.64	8.27
40	21.6	18.7	13.70	9.3	8.7	16.4	11.23	8.95	7.61	9.59	9.4	8.8	9.11	9.33	8.90
50	20.8	19.4	14.83	10.7	9.2	17.2	11.82	9.66	8.46	10.37	10.17	9.7	9.78	10.03	9.55
60	19.2	19.9	15.95	12.1	8.8	17.85	12.35	10.26	9.41	11.16	10.92	10.7	10.43	10.67	10.20
70	17.6	20.2	16.82	13.1	7.6	18.46	12.80	10.98	10.41	11.92	11.6	11.5	11.03	11.21	10.78
80	+16.4	+20.5	+17.31	+13.8	− 5.7	+18.97	+13.13	+11.91	+11.38	+12.60	+12.2	+12.3	+11.56	+11 63	+11.29
1885	+15.8	+20.5	+17.40	+14.1	− 4.5	+19.2	+13.25	+12.41	+11.84	+12.90	...	+12.6	+11.78	+11.78	+11.50

TABLE IV—Continued.

Year.	Providence, R. I.	Hartford, Conn.	New Haven, Conn.	Albany, N. Y.	Oxford, N. Y.	Buffalo, N. Y.	Toronto, Canada.	Erie, Pa.	Marietta, Ohio.	Cleveland, Ohio.	Detroit, Mich.	Sault de Ste. Marie, Mich.	Cincinnati, Ohio.	St. Louis, Mo.	New York, N. Y.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1600	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
30	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
50	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
60	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
70	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
80	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+8.8
90	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+8.8
1700	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+8.5
10	+10.4	....	....	....	....	....	....	....	....	....	....	....	....	....	8.0
20	9.5	....	....	....	....	....	....	....	....	....	....	....	....	....	7.6
30	8.9	....	....	....	....	....	....	....	....	....	....	....	....	....	7.2
40	8.4	....	....	....	....	....	....	....	....	....	....	....	....	....	6.6
50	7.7	....	....	....	....	....	....	....	....	....	....	....	....	....	5.9
60	6.9	....	+6.14	....	....	....	....	....	....	....	....	....	....	....	5.2
70	6.3	....	5.55	....	....	....	....	....	....	....	....	....	....	....	4.6
80	6.12	+ 5.4	5.00	....	....	....	....	+0.45	....	....	....	....	....	....	4.4
90	+ 6.24	+ 5.2	+4.79	....	+3.01	+0.25	....	−0.02	....	−2.0	....	+0.0	....	....	+4.26
1800	+ 6.37	+5.16	+4.67	....	+2.96	+0.03	....	−0.33	....	−1.9	−3.18	−0.5	−4.85	....	+4.25
10	6.45	5.24	4.74	+ 5.4	3.10	0.02	....	0.45	−2.8	1.7	3.11	0.9	5.00	−9.4	4.27
20	6.73	5.46	4.98	5.81	3.40	0.22	....	0.37	2.8	1.4	2.90	1.1	5.00	9.2	4.44
30	7.43	5.80	5.39	6.35	3.87	0.60	+0.8	−0.10	2.7	1.06	2.55	1.2	4.83	8.9	4.88
40	8.31	6.24	5.95	7.00	4.46	1.16	1.32	+0.34	2.3	0.61	2.09	1.04	4.52	8.4	5.56
50	9.09	6.77	6.61	7.74	5.14	1.85	1.61	0.92	1.86	−0.12	1.56	0.76	4.08	7.95	6.31
60	9.65	7.36	7.35	8.49	5.89	2.64	2.17	1.60	1.27	+0.38	0.99	−0.34	3.53	7.39	6.93
70	10.21	7.99	8.10	9.23	6.65	3.48	2.66	2.32	−0.60	0.87	−0.41	+0.21	2.92	6.83	7.40
80	+10.9	+8.62	+8.84	+ 9.90	+7.38	+4.32	+3.62	+3.04	+0.10	+1.31	+0.13	+0.84	−2.27	−6.28	+7.81
1885	....	+8.92	+9.19	+10.19	+7.73	+4.73	+3.88	+3.39	+0.45	+1.51	+0.37	+1.18	−1.95	−6.0	+8.03

TABLE IV—Continued.

Year.	Hatborough, Pa.	Philadelphia, Pa.	Harrisburg, Pa.	Baltimore, Md.	Washington, D. C.	Cape Henry, Va.	Charleston, S. C.	Savannah, Ga.	Key West, Fla.	Havana, Cuba.	Kingston, Jamaica.	Panama, New Granada.	Florence, Ala.	Mobile, Ala.	New Orleans, La.	Vera Cruz, Mexico.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1600	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
30	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
50	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
60	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
70	....	....	....	+5.7	....	....	....	....	....	....	....	....	....	....	....	....
80	+8.5	....	....	5.8	....	....	....	....	....	....	....	....	....	....	....	....
90	+8.3	....	....	+5.7	....	....	....	....	....	....	....	....	....	....	....	....
1700	+7.9	+8.9	....	+5.4	....	....	....	....	....	....	....	....	....	....	....	....
10	7.5	8.5	....	5.0	....	....	....	....	....	....	....	....	....	....	....	....
20	7.0	7.7	....	4.5	....	+4.4	....	....	....	−4.0	....	....	....	....	−3.3	−2.0
30	6.3	7.3	....	3.9	....	3.9	....	....	....	4.4	−6.2	....	....	....	3.6	2.9
40	5.6	6.6	....	3.2	....	+3.4	....	....	....	−4.9	−6.5	....	....	....	4.1	3.9
50	4.7	5.7	....	2.6	....	....	....	....	....	....	....	....	....	....	4.7	4.8
60	3.8	4.6	....	2.0	....	....	....	....	....	....	....	....	....	....	5.3	5.8
70	2.9	3.5	....	1.46	....	....	−4.7	....	....	....	....	−8.4	....	....	5.9	6.7
80	2.2	2.6	....	1.04	....	....	4.9	....	....	....	....	8.3	....	....	6.5	7.5
90	+1.8	+2.1	−0.05	+0.76	+0.0	....	−4.9	....	....	....	−6.3	−8.1	....	....	−7.0	−8.2
1800	+1.8	+1.9	+0.04	+0.64	+0.0	+0.3	−4.7	....	....	....	−6.1	−7.8	....	−5.8	−7.52	−8.7
10	2.03	2.11	0.35	0.68	0.1	0.1	4.4	−4.9	....	−6.5	5.7	7.6	−6.50	6.3	7.88	9.2
20	2.53	2.54	0.83	0.88	0.4	0.2	3.97	4.8	−6.7	6.3	5.3	7.3	6.58	6.73	8.11	9.4
30	3.17	3.07	1.45	1.23	0.8	0.35	3.44	4.5	6.48	6.1	4.9	7.04	6.54	6.99	8.18	9.4
40	3.86	3.63	2.17	1.70	1.26	0.68	2.84	4.14	6.06	5.8	4.5	6.76	6.37	7.09	8.10	9.27
50	4.57	4.18	2.94	2.27	1.83	1.14	2.20	3.65	5.52	5.42	4.1	6.47	6.11	7.01	7.88	8.95
60	5.29	4.76	3.71	2.90	2.44	1.70	1.56	3.08	4.88	4.99	3.7	6.20	5.74	6.77	7.52	8.46
70	6.0	5.45	4.43	3.55	3.05	2.31	0.95	2.48	4.18	4.54	3.3	5.9	5.30	6.38	7.05	7.82
80	+6.8	+6.26	+5.05	+4.17	+3.63	+2.94	−0.41	−1.89	−3.47	−4.09	−3.0	−5.7	−4.81	−5.86	−6.49	−7.05
1885	....	+6.70	+5.30	+4.47	+3.89	+3.25	−0.17	−1.60	−3.12	−3.9	....	....	−4.55	−5.56	−6.18	−6.6

TABLE IV—Continued.

Year.	Mexico, Mexico.	Acapulco, Mexico.	San Blas, Mexico.	Magdalena Bay, Lower Cal.	San Diego, Cal.	Monterey, Cal.	San Francisco, Cal.	Cape Disappointment, Wash. Ter.	Nee-ah Bay, Wash. Ter.
	°	°		°	°		°	°	°
1600	....	....	....	....	....	....	....	....	....
10	....	....	....	....	....	....	....	....	....
20	....	....	....	....	....	....	....	....	....
30	....	....	....	....	....	....	....	....	....
40	....	....	....	....	....	....	....	....	....
50	....	....	....	....	....	....	....	....	....
60	....	....	....	....	....	....	....	....	....
70	....	....	....	....	....	....	....	....	....
80	....	....	....	....	....	....	....	....	....
90	....	....	....	....	....	....	....	....	....
1700	....	....	....	....	....	....	....	....	....
10	....	....	....	....	....	....	....	....	....
20	....	....	....	....	....	....	....	....	....
30	....	....	....	....	....	....	....	....	....
40	....	−3.2	....	....	....	....	....	....	....
50	....	4.0	....	....	....	....	....	....	....
60	−5.2	4.9	....	....	....	....	....	....	....
70	5.9	5.7	....	....	....	....	....	....	....
80	6.9	6.5	....	....	....	−11.1	....	−17.9	....
90	−7.2	−7.2	−7.4	....	−11.0	−11.6	−12.8	−18.0	−18.9
1800	−7.78	−7.8	−7.8	....	−11.1	−12.2	−13.3	−18.2	−19.4
10	8.22	8.3	8.2	....	11.3	12.8	13.9	18.5	19.9
20	8.53	8.63	8.5	....	11.6	13.3	14.42	18.8	20.4
30	8.72	8.86	8.77	− 8.3	11.9	13.9	14.93	19.3	20.9
40	8.78	8.95	8.99	9.0	12.19	14.41	15.40	19.75	21.4
50	8.70	8.89	9.14	9.60	12.52	14.89	15.80	20.26	21.86
60	8.49	8.69	9.23	10.09	12.86	15.31	16.13	20.77	22.24
70	8.15	8.35	9.25	10.47	13.18	15.66	16.37	21.26	22.53
80	−7.70	−7.88	−9.20	−10.70	−13.47	−15.93	−16.52	−21.70	−22.71
1885	−7.4	−7.61	−9.1	−10.8	−13.60	−16.03	−16.56	−21.89	−22.75

TABLE IV—Continued.

Year.	Nootka Sound, Vancouver Island.	Kailua, Sandwich Islands.	Honolulu, Sandwich Islands.	Sitka, Alaska.	Unalashka, Alaska.	Petropavlovsk, Kamtchatka.	Port Mulgrave, Alaska.	Port Etches, Alaska.	St. Paul, Kadiak Island, Alaska.
	°	°	°	°	°	°	°	°	°
1600	....	....	....	....	....	....	....	....	....
10	....	....	....	....	....	....	....	....	....
20	....	....	....	....	....	....	....	....	....
30	....	....	....	....	....	....	....	....	....
40	....	....	....	....	....	....	....	....	....
50	....	....	....	....	....	....	....	....	....
60	....	....	....	....	....	....	....	....	....
70	....	....	....	....	....	....	....	....	....
80	....	....	....	....	....	....	....	....	....
90	....	....	....	....	....	....	....	....	....
1700	....	....	....	....	....	....	....	....	....
10	....	....	....	....	....	....	....	....	....
20	....	....	....	....	....	....	....	....	....
30	....	....	....	....	....	....	....	....	....
40	....	....	....	....	....	....	....	....	....
50	....	....	....	....	....	....	....	....	....
60	....	....	....	....	....	....	....	....	....
70	−20.0	−7.1	....	....	−18.3	−6.3	−22.7	−22.8	−22.2
80	20.3	7.8	....	−25.6	18.7	6.26	24.5	24.8	23.4
90	−20.6	−8.3	− 8.7	−26.1	−19.03	−6.06	−26.2	−26.7	−24.5
1800	−21.1	−8.7	− 9.3	−26.7	−19.31	−5.72	−27.8	−28.5	−25.5
10	21.5	9.0	9.8	27.3	19.54	5.25	29.3	30.0	26.4
20	22.0	9.2	10.1	27.81	19.70	4.69	30.41	31.1	27.0
30	22.4	9.3	10.3	28.28	19.78	4.06	31.24	31.73	27.32
40	22.8	9.2	10.3	28.66	19.77	3.39	31.71	31.92	27.38
50	23.13	9.0	10.2	28.94	19.68	2.72	31.78	31.61	27.15
60	23.38	8.6	9.9	29.08	19.51	2.08	31.45	30.84	26.65
70	23.54	8.1	9.4	29.09	19.27	1.51	30.74	29.64	25.91
80	−23.60	−7.6	− 8.8	−28.95	−18.97	−1.03	−29.69	−28.09	−24.97
1885	−23.59	−7.2	− 8.5	−28.84	−18.8	−0.83	−29.06	−27.21	−24.42

TABLE IV (*b*).

Year.	St. John's, Newfoundland.	Charlotte Town, Prince Edward Island.	Tyrone, Pa.	Pittsburg, Pa.	Chicago, Ill.	Grand Haven, Mich.	Madison, Wis.	Michipicoten, Ontario, Canada.	Duluth, Minn. and Superior City, Wis.
	°	°	°	°	°	°	°	°	°
1760	....	....	....	....	....	....	....	....	....
70	....	....	....	....	....	....	....	....	....
80	....	....	....	....	....	....	....	....	....
90	....	....	....	....	....	....	....	....	....
1800	....	....	....	....	....	....	....	....	....
10	....	....	....	....	....	....	....	....	....
20	....	....	....	....	−6.14	−5.01	....	−4.50	....
30	....	....	....	....	6.26	5.23	....	4.51	....
40	+28.94	+20.71	....	....	−6.23	−5.21	....	−4.14	....
50	30.35	22.07	....	....	6.03	4.95	....	3.38	....
60	31.10	22.96	....	....	5.67	4.45	....	2.24	....
70	31.21	23.39	+3.16	....	5.14	3.71	....	−0.71	−10.68
80	+30.66	+23.35	+3.71	+2.43	−4.45	−2.73	−6.45	+1.20	− 9.81
1885	+30.15	+23.17	+3.98	+2.72	−4.04	−2.15	−6.12	+2.29	− 9.38

TABLE IV (b).—Continued.

Year.	St. George's Town, Bermuda Island.	Rio Janeiro, Brazil.	San Antonio, Texas.	Omaha, Nebr. and Council Bluffs, Iowa.	Denver, Colo.	Salt Lake City, Utah.	Port Townshend, Wash. Ter.	Port Clarence, Alaska.	Chamisso Island, Alaska.
	°	°	°	°	°	°	°	°	°
1760	....	−7.86	....	....	....	....	....	....	....
70	....	7.39	....	....	....	....	....	....	....
80	....	6.81	....	....	....	....	....	....	....
90	....	−6.13	....	....	....	....	....	....	....
1800	....	−5.33	....	....	....	....	....	....	....
10	....	4.43	....	....	....	....	....	....	....
20	....	3.41	....	....	....	....	....	−26.7	−30.0
30	+6.90	−2.30	−10.45	....	....	....	....	−27.0	−30.6
40	+6.87	−1.06	−10.32	....	....	....	−20.45	−26.8	−30.7
50	6.95	+0.28	10.14	....	....	−15.51	21.38	26.4	30.4
60	7.16	1.73	9.91	....	....	16.26	21.90	25.6	29.7
70	7.48	3.28	9.64	−10.78	....	16.65	22.01	24.4	28.5
80	+7.93	+4.96	− 9.31	−10.34	−14.61	−16.68	−21.69	−22.9	−26.9
1885	+8.20	+5.83	− 9.14	−10.12	−14.48	−16.56	−21.37	−22.0	−26.0

Although the writer has made an attempt to investigate the secular variations of the magnetic dip* and of the magnetic horizontal intensity,† neither of these quantities admits at present of such precision and range as we are able to give to the discussion of the declination.

For the secular variation in the dip and intensity the application of a circular function in the place of an exponential function is as yet hopeless. The cause of this condition is sufficiently evident; with us, reliable observations for dip hardly date back to the year 1790 on the western coast, while on the eastern coast there are but few observations earlier than the year 1833. Respecting recorded horizontal intensities, but few determinations were made in the United States prior to 1830; these and other early observations are, of course, only of a differential character‡ which had first to be expressed in absolute measure before the results would be compared.

The two articles referred to give barely more than approximations to the values of the annual change, but from the accumulation of data during the last twenty years we may expect to be able to give greater precision to the values of the annual change as well as to gain some knowledge respecting its variability with geographical distribution.

*See preliminary investigation in Coast Survey Report for 1856, Appendices Nos. 32 and 33.

†See preliminary investigation in Coast Survey Report for 1861, Appendix No. 22.

‡In 1833 Gauss showed how the magnetic force could be expressed in absolute measure. In 1836 Professor Weber applied the principle to the small portable instruments, since in use; in 1838 he introduced the collimator magnet as proposed by Sir George B. Airy. For reference the English reader may consult vol. ii of R. Taylor's Scientific Memoirs, London, 1841.

APPENDIX No. 13.

DISTRIBUTION OF THE MAGNETIC DECLINATION IN THE UNITED STATES AT THE EPOCH JANUARY, 1885, WITH THREE ISOGONIC CHARTS.

By CHARLES A. SCHOTT, Assistant.

[One plate.]

COMPUTING DIVISION, *December* 30, 1882.

Of late years the magnetic work of the Survey, both in the field and in the office, having been pushed forward very actively, as may be seen by the recent publication of results, it appeared equally desirable to bring this new material into use at the earliest practicable moment. Of the new results those of the declination are the most important, since by means of them the compass cards are supplied for our sailing, coast, and harbor charts, and it had lately become necessary to construct, provisionally, an isogonic chart for the epoch of 1880 in order that the desired accuracy could be given to the nautical data thus furnished.

By taking a short retrospect of what has been done by the Survey in this direction, the progress made in our knowledge of this branch of terrestrial physics will become apparent. In consequence of the slow changes in the earth's magnetic condition, and the gradual accumulation of data, the reconstruction from time to time of tables of magnetic declination or of charts of equal magnetic declination (isogonic charts) becomes a necessity, and consequently publications will be found in several of our annual reports.

The first table of results *with an isogonic chart* was published by A. D. Bache and J. E. Hilgard in the Report for 1855, see Appendix No. 47 and Plate No. 56. The declinations were reduced to a common epoch, viz: 1850 by means of assumed values of the annual change and for convenience of discussion the declinations were arranged in geographical groups, which were separately treated by application of Dr. Lloyd's interpolation formula.* The table comprises 153 stations, and the curves computed for each whole degree cover but a narrow strip along the coast line. In the following year the same authors produced a new chart, retaining, however, the epoch 1850; it is the result of a more extended discussion, including all recent observations (see Report for 1856, Appendix No. 28), and on the chart (Plate No. 61) the isogonic curves fairly cover the area of the Eastern States, as well as the area bordering on our Pacific coast, and they appear connected along the line of the Mexican boundary. The curves are compared with those resulting from Gauss' general theory of terrestrial magnetism, published in 1838. The average epoch of the data used by Gauss is about 1829, and the authors notice the accord in the *form* of the curves with those over the same area and resting on observations made up to 1850. It is well known that in the general theory Gauss used 24 coefficients, depending on observations distributed over the greater part of the accessible surface of the globe, and including declinations, dips and intensities. A

* Proposed by Dr. Lloyd, of Dublin, in 1838, see eighth report of Brit. Asso., Vol. VII, p. 91, and following; also note by Archibald Smith in Lieut. Col. E. Sabine's contribution to terrestrial magnetism, VII, in Phil. Trans. Roy. Soc., Part III, 1846, p. 248, and following.

late attempt made by Erman and Petersen (Berlin, 1874) to introduce into this theory additional material, and to reduce the same to the epoch 1829 by a strict account of the secular variation, has not resulted, to any marked degree, in a change in the curves as originally given by Gauss. Comparisons were also made with Barlow's chart, Phil. Trans. Roy. Soc., 1833 (Part II, p. 667, and following), and with Prof. E. Loomis' chart for 1840, Silliman's Journal Sc. and Arts, Vol. XL; the latter is the first detail chart extending some distance into the interior of the country. Lieut. Col. E. Sabine's chart for 1840, Phil. Trans. Roy. Soc., 1849 (Part II, p. 173, and following) shows the distribution of the declination over the Atlantic Ocean, and was of assistance in giving direction beyond the coast line to our curves, which depend exclusively on observations made on land.

The Report for 1861, Appendices Nos. 23 and 24, contains two small isogonic charts (Plate No. 30); they were designed as aids to navigation, and refer to our Southern Atlantic and to our Gulf coast; epoch, 1860.

The Report for 1862, Appendix No. 19, gives an account of a magnetic survey of the State of Pennsylvania, and on Plate No. 47 isomagnetic lines are laid down for the two epochs, 1842 and 1862.

The next isogonic chart accompanies Appendix No. 19, Plate No. 27, of the Report for 1865; it is on a larger scale and covers about the same area as the chart of 1856, but embodies the results accumulated since that time and later data respecting the secular variation. The epoch is 1870, and it was constructed by the present writer.

The latest chart, prior to the present, issued by the Survey is that of Plate No. 24, Report for 1876, Appendix No. 21, by J. E. Hilgard. This chart, which refers to the epoch 1875, not only embodies the results of the Survey up to 1877, but uses about 200 recent observations obtained under the auspices of the National Academy of Sciences, and made under his immediate direction. Besides, a number of results from Government surveys and from private sources were utilized, and for the reduction to the epoch 1875 the researches contained in the third edition of my paper on the secular change (1879), the second edition of which appeared in the Report for 1874, Appendix No. 8, were made use of. The isogonic curves are given for each degree of declination and they cover the whole area of the United States [excepting Alaska]. The size of the chart is very much larger than that of its precursor, and was demanded by the necessity of representing all the facts then known. The former curves were brought forward by the known secular change, and reconstructed by a graphical process where new data had been obtained; thus giving the latest information at the date of publication. The chart exhibits, especially in the eastern and middle parts, certain slight irregularities in the form of the curves, which are due to local deflection or disturbed regions.

For some years past, but particularly since July, 1878, when the designation "Coast Survey" was changed to "Coast and Geodetic Survey," I have incidentally collected and put on record all magnetic results coming under my notice, comprising declinations, dips and intensities, no matter when taken, but referring to the area of the United States or to the vicinity of its borders, thus including parts of Canada, British North America, the West Indies, Mexico and the region about Alaska. This collection, made up from all accessible sources, comprises several thousand entries, and I proposed to use all its declinations suitable for the purpose, as well as the complete material from observations by the Coast and Geodetic Survey,* for the production of a new isogonic chart.

The chart now presented and answering to the epoch 1885, January 1, differs from the preceding charts by taking distinct notice of all local disturbances in the direction of the magnetic needle, and, so far as such regions could be recognized, by showing the extent and amount of the local deflections. Heretofore it had been customary to present through the familiar geometrical lines the distribution of magnetism as if it were regular, but the increased material at our command renders it now possible and imperative to attempt the delineation of the actual distribution. Such geometrical representation had even been regarded by some as the true representation of facts, whereas the curves are affected not only by irregularities quite local, but also by such as extend over many square degrees of surface. The former are difficult to distinguish from errors of observation, but the latter can be recognized by the greater or less regularity of the curves when traversing the region, and by the concordant results of several observers, whose observations, made at different epochs, were reduced to 1885. There are also marked on the chart, by dots, all places

* Report for 1881, Appendix No. 9.

of observation, and by reference to the table, presently to be explained, it can at once be ascertained by whom and when any particular observation was made.

Preparatory to the production of the new chart, it became desirable to have reference to three papers intimately connected with the subject, viz: First, a new edition (the third) of "Directions for measurement of terrestrial magnetism," in the Report for 1881, Appendix No. 8; secondly, a new edition (the fifth) of "Secular variation of the magnetic declination in the United States," in the Report for 1882, Appendix No. 13; and thirdly, a paper entitled "Collection of results for declination, dip, and intensity from observations made by the United States Coast and Geodetic Survey, between 1833 and July, 1882, given in the Report for 1881, Appendix No. 9. The first of these papers explains the method and describes the instruments as used on the Survey; the second paper contains the data and results which enabled me to refer all observations to the common epoch of the chart; for this purpose Tables IV (*a*) and (*b*) of that paper were extended so as to give the declinations for every year. Each annual value was then substracted from its corresponding value for 1885.0, and the new set of secular variation-tables thus formed possessed the great advantage of giving at once the reduction to epoch, and of permitting comparisons of this quantity for adjacent stations by mere inspection; also of affording the means of easy interpolation for geographical position relative to stations represented in the table. The third paper furnishes part of the material for the basis of the new chart.

TABLES OF OBSERVED MAGNETIC DECLINATIONS AND CORRESPONDING VALUES REFERRED TO EPOCH, JANUARY, 1885.

Its contents are arranged according to States and Territories, and there are generally two parts for each of these political subdivisions, viz, the first composed entirely of Coast and Geodetic Survey declinations and the second of declinations derived from all other sources. Only the *latest* observation is given at all places where there is more than one result, in order that the reduction to epoch may be given with the greatest accuracy possible for the locality. The columns contain, in the order given, the following information: The name of the station; its latitude; its longitude; the time of observation; the declination; the reduction to epoch; the result referred to 1885.0; the observer's name, and reference where record is found. The table was prepared by myself, with the exception of the columns headed $\triangle$ D and $D_{1885\cdot0}$, which were filled up by Dr. J. G. Porter, of the Computing Division. The geographical positions are generally given on the authority of the observer, but they were corrected in all cases where means existed for their improvement. In a number of instances the geographical positions had to be supplied, and there remain many results in the general collection which could not be transferred to the table for want of this information. The date is expressed in years and fractions of a year; the declination is given in degrees and fractions of a degree, with the signs + when west and — when east. For Parts I (Coast and Geodetic Survey results) the columns for observer and reference are omitted, full information being given in the third paper referred to above.

The total number of stations contained in the table is 2359, and with the exception of some stations for which proper reduction to epoch could not be had, and of others lying too far off the boundaries of the charts, their results were laid down on the base chart of the Survey, in two sheets, scale one five-millionth, and those for Alaska were laid down on a chart of smaller scale suitable to the comparatively sparse number of results in that Territory. For the plotting of the stations and the insertion of the numbers of column headed D_{1885} I am indebted to Mr. A. Ziwet, of the Computing Division. The data being thus prepared, I constructed by a graphical process the isogonic curves for the eastern and western part of the United States—at first following up all irregularities, next reviewing the curves and straightening them out so far as seemed allowable in consideration that the irregularity may have been the result of observing error, and was thus only an apparent one, but there were also cases where the deviations were of such evident local character and circumscribed (say a few square minutes) area that they could find no place on the chart. Whenever concurrent testimony clearly pointed out magnetically disturbed regions of considerable area (say a number of square degrees) I have traced them out and defined them by curves. Among the irregularities presented some may be due, at present, to undetected systematic errors of observation, or to imperfect knowledge of the secular variation; these, however, may easily be recognized by means of new observations. In two localities in particular, where the isogonic curves, as first drawn, appeared unusually deflected, the results by other observers in the vicinity of these regions pointed to defects which were traced, in one case, to an instrumental error in the nature of an index error affecting a series of stations of that season, and in the other case to a defective reduction to epoch applied in a region where data was very imperfect; after correction, the curves assumed quite regular shapes. Much difficulty was experienced in tracing out the lines on the Pacific coast and generally west of the 105th meridian; in this part of the country observations require to be greatly multiplied, and some time must necessarily elapse before the law of the annual change can become better known. The minor irregularities in the distribution of magnetism, as shown on the chart for the New England States, and for the State of Missouri, may be taken as fairly made out. Of the latter State an admirable special magnetic survey has been prosecuted through private enterprise* for some years, and is now nearly complete.

Prominent among those who have made local magnetic disturbances a special study were Dr. John Locke, in this country, and the late Dr. Lamont, in Germany. In the spring and summer of 1844, Dr. Locke examined experimentally into the local distribution of magnetism about the Palisades, N. J., and presented his results by diagrams of isoclinic and isodynamic curves.† Dr. Lamont, in a work entitled "Researches of the direction and intensity of terrestrial magnetism in Northern Germany, Belgium, Holland, and Denmark, executed by Dr. J. Lamont, in the summer of the year 1858 (Munich, 1859), gives expressions of the effect of a given disturbance on the direction and intensity experienced by a magnetic needle, and gives diagrams of the consequent deformation produced in the isogonic, the isoclinic, and the isodynamic curves over the perturbed region. Since these formulæ do not appear to be so well known as their importance deserves, and on account of their instructive application to the iso magnetic curves, I give here a free translation of part of contents of page 21 of the preface:

Suppose a magnetic south pole of intensity P vertically below the point A on the earth's surface, and at a depth equal to unity, and it be required to determine its effect upon the magnetism at a second point, B, on the surface distant from A equal to r and in azimuth ψ reckoned from magnetic north round by west, then the effect of the pole P at the point B will be

$$\text{in declination} = -\frac{P}{H \sin 1'} \cdot \frac{r \sin \psi}{(1+r^2)^{\frac{3}{2}}} \text{ expressed in minutes}$$

$$\text{in horizontal intensity} = -P \cdot \frac{r \cos \psi}{(1+r^2)^{\frac{3}{2}}} \text{ in absolute measure}$$

$$\text{and in dip} = \frac{P}{H \sin 1'} \cdot \frac{\cos \theta (\cos \theta + r \cos \psi \sin \theta)}{(1+r^2)^{\frac{3}{2}}} \text{ in minutes}$$

where H= the horizontal force and θ= the dip.

These formulæ are approximations, but quite close enough for the purpose intended.‡ Applied to a case in Middle Europe. Dr. Lamont shows that the curves of horizontal intensity to the magnetic north and south of the center of disturbance are bent inwards or toward it, and that the curves of equal declination to the east and west of the disturbance are bent outwards or away from it, whereas the curves of equal dip are bent southward, directly over the point of disturbance,

*Aided instrumentally by the Coast and Geodetic Survey.

†Transactions American Philosophical Society, Phila., Vol. IX, 1846.

‡We have distance $PB = (1+r^2)^{\frac{1}{2}}$ and $\cos ABP = \frac{r}{(1+r^2)^{\frac{1}{2}}}$, and remembering that attractions and repulsions of magnetic quantities are inversely as the square of their distance, and consequently that the *disturbing* effect of magnetic energy upon a magnetic needle is inversely as the cube of their distance, the disturbing force in the direction AB becomes $-\frac{Pr}{(1+r^2)^{\frac{3}{2}}}$ and the disturbing force acting at right angles to the needle, when expressed in parts of the horizontal force, $-\frac{P}{H} \cdot \frac{r \sin \psi}{(1+r^2)^{\frac{3}{2}}}$; hence the expression for angular disturbance in declination expressed in minutes, as given above.

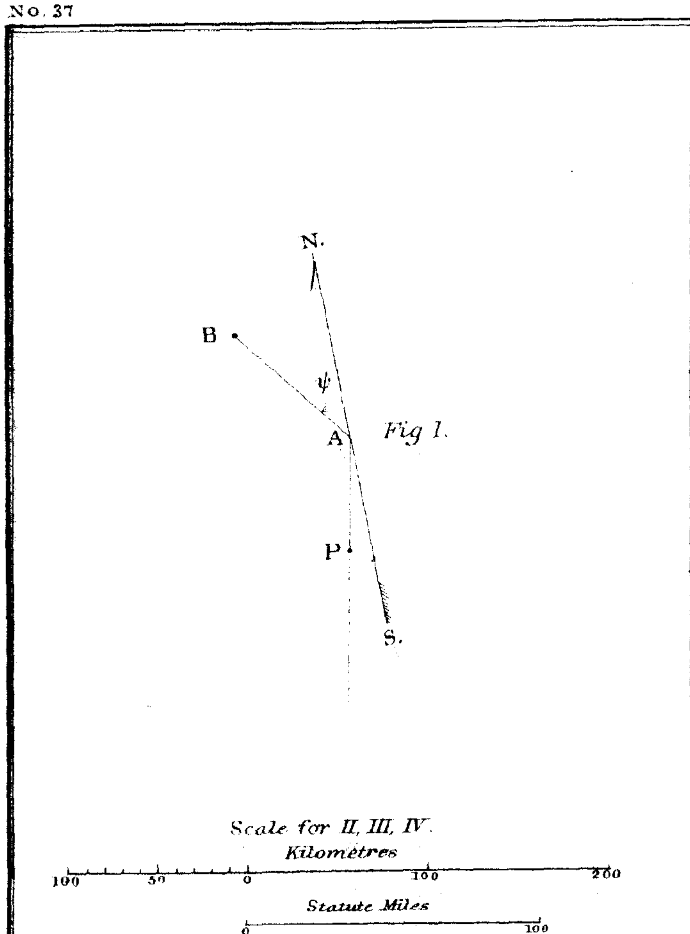
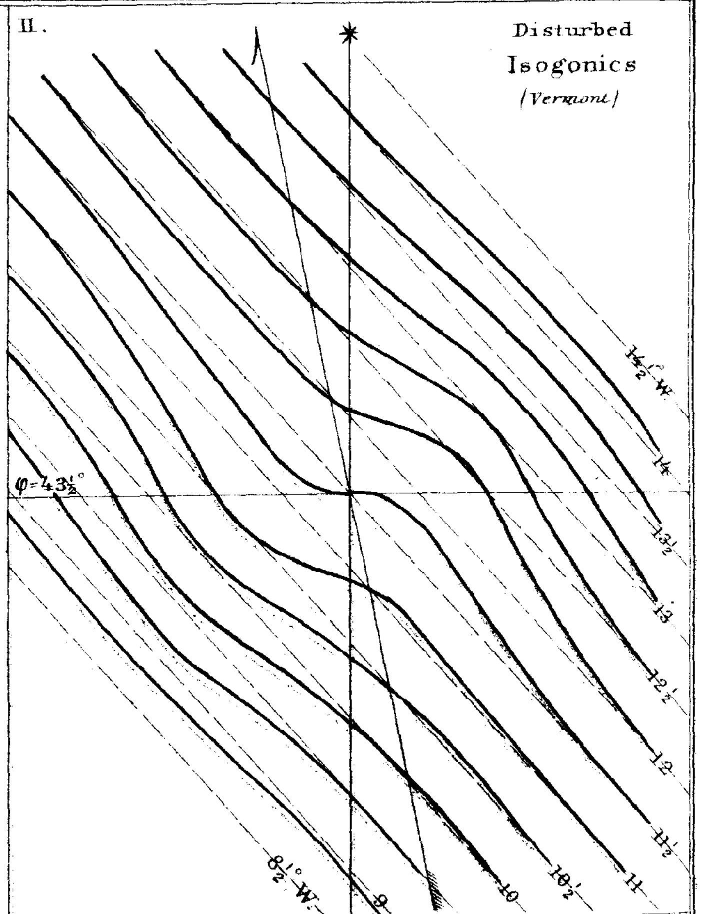
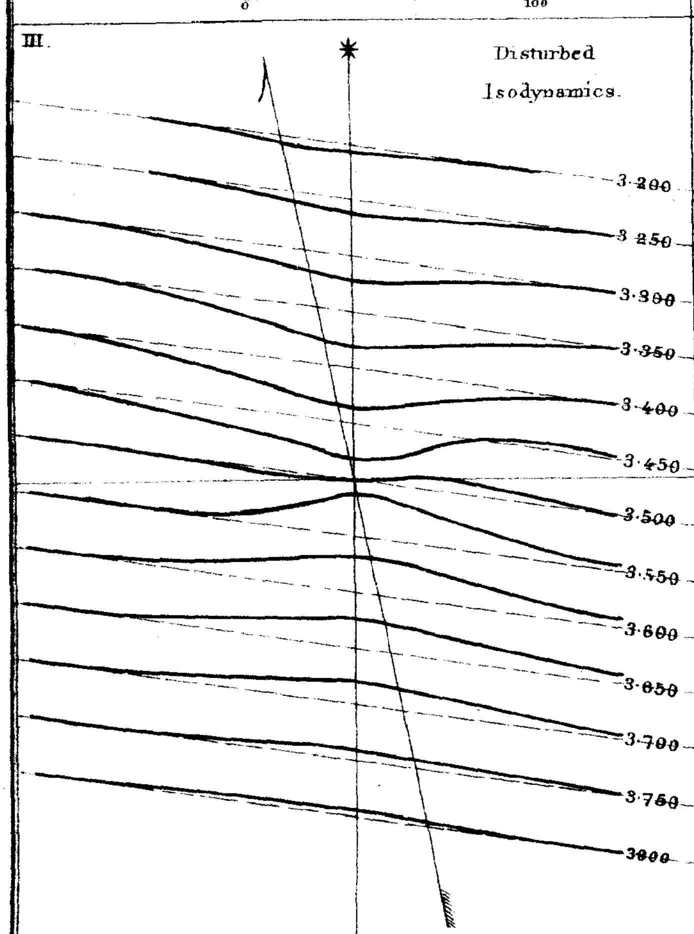
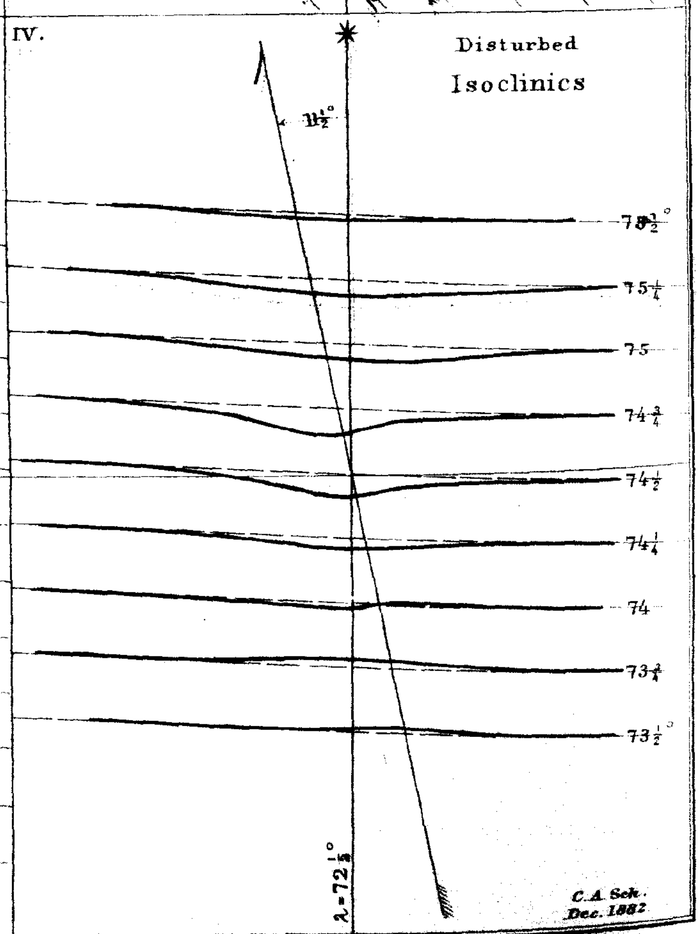

N.
B
ψ
A
P
S.
Scale for II, III, IV.
Kilometres
100 50 0 100 200
Statute Miles
0 100

Fig 1.


II.
Disturbed
Isogonics
(Vermont)
φ=43½°
14½° W.
14
13½
13
12½
12
11½
11
10½
10
9
8½° W.


III.
Disturbed
Isodynamics.
3·200
3·250
3·300
3·350
3·400
3·450
3·500
3·550
3·600
3·650
3·700
3·750
3·800


IV.
Disturbed
Isoclinics
11½°
75½°
75¼
75
74¾
74½
74¼
74
73¾
73½°
λ=72½°
C.A. Sch.
Dec. 1882.

as well as to the north of it, also up to a certain distance to the south of it. Supposing the isomagnetic curves over a disturbed region given by observation, the position of the point on the surface vertically above the point of disturbance, that is its latitude and longitude, may be found from the disturbed declination and intensity curves, and the depth of the point of disturbance from the dip curves, the intensity of the disturbance being determined by the amount of bending of the curves. After commenting on the highly instructive nature of the application of the formulæ when thrown into curves, he remarks: "It is, however, not to be imagined that the irregularities in the magnetic curves are produced by a single pole of disturbance, such as has been supposed above, but rather by a series of such poles forming peaks or ridges of disturbance." In fact the distribution in space of disturbing poles and their intensities must be taken as indefinitely variable and their joint effect may give rise to a great variety of deformations. "To follow them up to their source in any special case would necessarily require observations at a great number of points closely packed over the region under investigation."

To illustrate the use of these formulæ, I have applied them to a disturbed region, and assuming the position, depth, and intensity of a magnetic pole, have computed the deformations of the isogonic, isoclinic, and isodynamic curves for the purpose of comparing them with their corresponding curves as deduced from observations. The region selected is in Southern Vermont, and the computation is made for $\varphi=43\frac{1}{2}°$, $\lambda=72\frac{1}{2}°$, at which place the declination $D=+11\frac{1}{2}°$, the dip $\theta=74\frac{1}{2}°$, and the horizontal intensity in British units $H=3.50$. The distances apart of the isomagnetic lines under the supposition of equable distribution of magnetism were taken from charts, as well as their azimuths, as presented on the diagrams of the accompanying plate No. 37, where these respective systems of lines are shown by dashes. The disturbing pole is supposed to be 60 kilometres below the surface (a little over 37 statute miles), its magnetism is assumed to be of south polarity, the same as that of the northern magnetic hemisphere, and its intensity is supposed equal to one-fortieth of that of the horizontal force. With these assumptions the formulæ give the theoretical deformed curves as shown in full lines on plate No. 37, and it will be seen that these disturbed systems of isomagnetic curves conform, with respect to curvature, to what has been stated to hold for Central Europe; also that the deflections of the dip curves are less in amount than those of the horizontal intensity and of the declination. The maximum deflection nearly approaches half a degree for the declination, 0.030 for the horizontal intensity and seven minutes for the dip. This would indicate that the above assumption as to depth and intensity of disturbing pole is quite a moderate one. The diagrams are drawn to scale and the disturbing effect upon the direction of the horizontal needle is still perceptible beyond the region included within the area of a circle of radius 160 kilometres (about 100 statute miles), and a comparison in this region of the curvature of the theoretical or disturbed isogonics with the actual curvature of the isogonics as derived from observation and given on the chart, indicates a general conformity, which by suitable changes in the assumptions might be more closely approximated.

With respect to Alaska, a different treatment for the construction of the isogonic curves had to be adopted from that employed for the eastern and western parts of the United States. The graphical process fails for Alaska, for the reason that the observations are not sufficiently numerous and do not cover the region with regularity; further, in many parts the reduction to epoch is so uncertain that the results would be of little value. We are therefore compelled to have resort to an analytical process in which the difficulties and uncertainties of the graphical process are replaced only by greater laboriousness.

To make use of all observations would neither be practicable nor advisable; we therefore exclude from analytical treatment all the older observations, retaining only quite modern ones, in order that the effect of imperfect knowledge of the secular variation may be a minimum; we further group the observations so as to distribute them, as near as may be, evenly over the surface under investigation. In order that these groups may have the required range in latitude and longitude, and for the purpose of introducing sufficient data into our problem, it was necessary to bring in some observations taken at sea. These observations are further exceptional, inasmuch as they include results of 1850 (about), whereas all other results hardly go back ten years from the present time.

With a view of expressing the declination D_{1885} as a function of the latitude φ and the longitude λ of the place, the following table of selected results has been formed:

No.	Name of station.	Latitude. °	′	Longitude. °	′	Time of observation.	Declination.	Reduction.	Declination, 1885.0. °	Remarks.
1	Nootka Sound	49	36	126	38	....	....	....	−23.59	Nos. 1 to 9, inclusive, secular variation stations. For results see table of 5th edition of secular variation. Appendix No. 12.
2	Sitka	57	03	135	20	....	....	....	−28.84	
3	Port Mulgrave	59	34	139	46	....	....	....	−29.06	
4	Port Etches	60	21	146	38	....	....	....	−27.21	
5	Saint Paul, Kadiak Island	57	48	152	21	....	....	....	−24.42	
6	Chamisso Island	66	13	161	49	....	....	....	−26.00	
7	Point Spencer, Port Clarence	65	16	166	51	....	....	....	−22.00	
8	Unalashka	53	53	166	32	....	....	....	−18.80	
9	Petropavlovsk	53	01	201	19	....	....	....	− 0.83	
10	Plover Bay	64	22	173	22	1880.66	−18.42	+0.78	−17.64	
11	Port Simpson	54	34	130	23	1881.61	−27.90	+0.06	−27.84	
12	Rose Harbor	52	09	131	15	1881.72	−26.01	+0.05	−25.96	
	Wrangell Land, east	71	04	177	40	1881.61	−23.43	+0.62	−22.81	Wrangell Land group.
	Wrangell Land, south	70	57	178	10	1881.65	−20.00	+0.62	−19.38	
	At sea, off Herald Island	70	49	174	32	1881.58	−24.78	+0.62	−24.16	
	At sea, off Herald Island	70	51	175	40	1881.58	−23.43	+0.62	−22.81	
13	Mean	70	55	176	30	....	....	....	−22.29	
	At sea, off Koliutchin	67	58	175	14	1881.42	−23.50	+0.65	−22.85	Koliutchin group.
	At sea, off Koliutchin	67	52	175	18	1881.60	−19.82	+0.62	−19.20	
14	Mean	67	55	175	16	....	....	....	−21.02	
	At sea, off Cape Lisburne	68	50	165	10	1881.57	−32.07	+0.62	−31.45	Cape Lisburne group, W=2.
	Near Cape Lisburne	68	53	166	06	1880.64	−25.71	+0.78	−24.93	
15	Mean	68	52	165	38	....	....	....	−27.10	
	Near Icy Cape	70	13	162	15	1880.65	−30.10	+0.78	−29.32	Icy Cape group.
	At sea, off Icy Cape	70	15	161	55	1881.55	−32.20	+0.62	−31.58	
	At sea, off Icy Cape	70	05	162	06	1881.56	−32.23	+0.62	−31.61	
16	Mean	70	11	162	05	....	....	....	−30.46	
	Off Point Barrow	71	20	156	15	1881.63	−37.30	+0.61	−36.69	Point Barrow group.
	Point Barrow	71	21	156	17	1854.00	−41.00	+2.80	−38.20	
	Ooglaamie	71	17	156	40	1881–'82	....	....	....	
17	Mean	71	20	156	16	....	....	....	−37.45	
18	Chichagoff Harbor, Attu Island	52	56	186	48	1873.48	− 7.72	+0.44	− 7.28	
19	Kyska Harbor	51	59	182	30	1873.55	−11.11	+0.44	−10.67	
20	Adakh Island	51	49	176	52	1873.61	−13.87	+0.40	−13.47	
21	Atka Island	52	11	174	15	1873.65	−16.96	+0.39	−16.57	
	Humboldt Harbor	55	19	160	31	1880.55	−20.28	+0.32	−19.96	Shumagin Islands group.
	Chiachi Island	55	52	159	05	1874.48	−21.93	+0.72	−21.21	
	Little Koniushi Island	55	03	159	23	1880.54	−21.42	+0.32	−21.10	
	Port Moeller	55	55	160	35	1874.61	−21.37	+0.72	−20.65	
22	Mean	55	32	159	54	....	....	....	−20.73	
23	Nunivak Island	60	25	166	08	1874.58	−21.56	+1.06	−20.50	
	At sea	48	49	201	47	1849.5	− 4.38	+1.92	− 2.46	Group off the Kuril Islands.
	At sea	47	28	200	15	1849.5	− 4.00	+1.92	− 2.08	
24	Mean	48	08	201	01	....	....	....	− 2.27	
	At sea	48	34	195	22	1851.5	− 7.17	+1.80	− 5.37	Group off south'n Kamtchatka.
	At sea	50	50	193	23	1850.5	− 5.90	+1.83	− 4.07	
	At sea	51	51	191	22	1854.5	− 8.60	+1.60	− 7.00	
	Mean	50	26	193	22	....	....	....	− 5.48	

No.	Name of station.	Latitude.		Longitude.		Time of observation.	Declination.	Reduction.	Declination, 1885.0.	Remarks.
		°	′	°	′				°	
	At sea	59	32	186	48	1849.5	−10.47	+2.75	− 7.72	Cape Olintorsk group.
	At sea	59	38	188	50	1849.5	−10.90	+2.75	− 8.15	
	At sea	59	05	190	11	1849.5	−10.28	+2.75	− 7.53	
	At sea	58	19	190	52	1849.5	− 9.68	+2.75	− 6.93	
26	Mean	59	08	189	10				− 7.58	
27	Saint Paul's Island	57	07	170	19	1880.60	−17.65	+0.25	−17.40	
	Thompson River	50	46	121	05	1871.5	−23.50	+0.04	−23.46	Thompson River group.
	Mouth of Nicola River	50	27	121	22	1871.5	−25.50	+0.04	−25.46	
	Mouth of Thompson River	50	13	121	36	1871.5	−25.00	+0.03	−24.97	
	Town of Yale	49	34	121	25	1871.5	−24.00	+0.04	−23.96	
	Mouth of Hut Creek	50	47	121	33	1873.5	−27.00	+0.03	−26.97	
28	Mean	50	21	121	24				−24.96	
	At sea	48	08	146	39	1827.5	−22.58	+1.90	−20.68	Northeast Pacific group.
	At sea	48	44	143	23	1827.5	−23.02	+1.90	−21.12	
	At sea	51	46	152	36	1830.5	−24.08	+1.60	−22.48	
	At sea	45	19	160	00	1850.0	−17.77	+1.50	−16.27	
	At sea	45	14	159	41	1850.0	−18.75	+1.50	−17.25	
29	Mean	47	50	152	28				−19.56	

Contracting the above table we obtain for our discussion the following data:

No.	ϕ	λ	D	No.	ϕ	λ	D	No.	ϕ	λ	D
	°	°	°		°	°	°		°	°	°
1	49.60	126.63	−23.59	10	64.37	173.37	−17.64	19	51.98	182.50	−10.67
2	57.05	135.33	−28.84	11	54.57	130.38	−27.84	20	51.82	176.87	−13.47
3	59.57	139.77	−29.06	12	52.15	131.25	−25.96	21	52.18	174.25	−16.57
4	60.35	146.63	−27.21	13	70.92	176.50	−22.29	22	55.53	159.90	−20.73
5	57.80	152.35	−24.42	14	67.92	175.27	−21.02	23	60.42	166.13	−20.50
6	66.22	161.82	−26.00	15	68.87	165.63	−27.10	24	48.13	201.00	− 2.27
7	65.27	166.85	−22.00	16	70.18	162.08	−30.46	25	50.43	193.37	− 5.48
8	53.88	166.53	−18.80	17	71.33	156.27	−37.45	26	59.13	189.17	− 7.58
9	53.02	201.32	− 0.83	18	52.93	186.80	− 7.28	27	57.12	170.32	−17.40
								28	50.35	121.40	−24.96
								29	47.84	152.46	−19.56

The position of these groups is shown by dots on the accompanying magnetic chart of the Alaskan region.

To reach by a single interpolation formula the isogonics for so extended an area as Alaska, the Bering Sea, and adjacent waters of the North Pacific and Arctic Oceans, we need to introduce additional terms in Lloyd's formula, as usually employed, and have

$$D=D_0+r\Delta\varphi+s\Delta\lambda\cos\varphi+t\Delta\varphi^2+u\Delta\varphi\Delta\lambda\cos\varphi+v\Delta\lambda^2\cos^2\varphi+w\Delta\varphi^3+x\Delta\varphi^2\Delta\lambda\cos\varphi$$
$$+y\Delta\varphi\Delta\lambda^2\cos^2\varphi+z\Delta\lambda^3\cos^3\varphi$$

$$\text{Put}\begin{cases}\varphi-\varphi_0=\Delta\varphi=\varphi_1\\ \lambda-\lambda_0=\Delta\lambda=\lambda_1\\ D_0=D_1+q\end{cases}\qquad \text{and assume}\ \begin{aligned}\varphi_0&=60^\circ\\ \lambda_0&=160^\circ\\ D_1&=-23^\circ\end{aligned}$$

then the conditional equations take the form

$$\begin{aligned}0=&D_1-D+q\\ &+r\varphi_1+s\lambda_1\cos\varphi\\ &+t\varphi_1^2+u\varphi_1\lambda_1\cos\varphi+v\lambda_1^2\cos^2\varphi\\ &+w\varphi_1^3+x\varphi_1^2\lambda_1\cos\varphi+y\varphi_1\lambda_1^2\cos^2\varphi+z\lambda_1^3\cos^3\varphi\end{aligned}$$

There are 29 such equations, and from these we form the normal equations, as usual in the method of least squares, and solving these the ten quantities, q to z, become known.

Thus the first conditional equation becomes—

$$0=+0^{\circ}.59+q-10.40r-21.63s+108.2t+225.0u+467.9v-1125w-2340x-4866y-10120z$$

and similarly we find the others. The normal equations are:

n	q	r	s	t	u	v	w	x	y	z
0 = − 90.02	+29	−59.1	+51.6	+ 1623	− 164	+ 4897	− 4152	+ 4332	− 37607	+ 18696
0 = + 1159	......	+1623	− 164	− 4152	+ 4332	− 37607	+ 148550	− 17985	+ 362650	− 177980
0 = − 2761	......	......	+4897	+ 4352	− 37607	+ 18696	− 17985	+ 362650	− 177980	+ 2139860
0 = − 5619	......	......	......	+148550	− 17985	+ 362650	− 413700	+ 408200	− 3405500	+ 2036800
0 = + 20108	......	......	......	......	+362650	− 177980	+ 408200	− 3405500	+ 2036800	− 19374600
0 = − 43418	......	......	......	......	......	+2139860	− 3405500	+ 2036800	− 19374600	+ 14134500
0 = + 110385	......	......	......	......	......	......	+15968200	− 2318700	+ 35712500	− 22768800
0 = − 188000	......	......	......	......	......	......	......	+35712500	− 22768800	+ 190197200
0 = + 386630	......	......	......	......	......	......	......	......	+190197200	− 143727600
0 = − 1199150	......	......	......	......	......	......	......	......	......	+1173326900
Values.....	+.400	−.432	+.867	−.0290	+.0602	+.0147	−.00209	+.00175	+.000608	−.000014

For brevity's sake the side-coefficients are not repeated below the diagonal line, a fact which is indicated by underscored diagonal coefficients. We have the equation

$$\begin{aligned}D=&-22^{\circ}.60-.432\ \varphi_1+.867\ \lambda_1\cos\varphi\\&-.0290\ \varphi_1^2+.0602\ \varphi_1\lambda_1\cos\varphi+.0147\lambda_1^2\cos^2\varphi\\&-.00209\varphi_1^3+.00175\varphi_1^2\lambda_1\cos\varphi+.000608\varphi_1\lambda_1^2\cos^2\varphi-.000014\lambda_1^3\cos^3\varphi\end{aligned}$$

with the residuals for the several groups, as follows:

	Res. °		°						
1	−.56	7	−.31	13	−1.24	19	−.52	25	−.35
2	+.21	8	+.56	14	+1.13	20	−.24	26	+.67
3	−.46	9	+.03	15	+.13	21	+.174	27	+.23
4	−.77	10	−.27	16	−.55	22	−.36	28	+.23
5	−.17	11	+.32	17	+1.12	23	+.56	29	−.13
6	+.05	12	+.29	18	−1.79	24	+.42		

hence probable error of any single observed value,

$$e_0=\sqrt{\frac{.455\Sigma\Delta^2}{n-m}}=\sqrt{\frac{.455\times 14.13}{29-10}}=\pm 0^{\circ}.58$$

a value which, in consideration of the high latitudes, the volcanic character of the Aleutian Islands, the sources from which many observations are drawn, and the uncertainty in the value of the secular variation, may be accepted as satisfactory.

The above equation contains the whole distribution of the magnetic declination in Alaska, as shown by the curves on the third of the accompanying magnetic charts, but the limits of applicability there presented should not be transgressed. It is easy to find roots of the equation by the method of trial and error; thus, for any given value or desired isogonic line of D°, we either assume φ and find the corresponding λ to it, or assume λ and find φ, the former when the isogonic makes a large angle with the parallel of latitude, the latter when it makes a small angle therewith. For instance, for the curve of -25° we have the intersections

°	°	°	°
φ=51.0	λ=130	φ=60	λ=154.2
51.7	135	65	161.4
54.7	145	70	171.7
		73	180.9
(Computed.)	(Assumed.)	(Assumed.)	(Computed.)

and so on for any other curve.

It will be noticed that the northeastern part of the Asiatic agonic now traverses the peninsula of Kamtchatka,* which is in conformity with the general easterly motion of the isogonics of the Bering Sea.

TABLE OF MAGNETIC DECLINATIONS, FOR THE MOST PART OBSERVED IN THE PRESENT CENTURY, REDUCED TO THE EPOCH JANUARY 1, 1885.

[Forming the basis for the construction of the accompanying three isogonic charts of the United States.]

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
ALABAMA, PART 1.	° ′	° ′		°	°	°		
Fort Morgan	30 14	88 01	1847.40	− 7.07	+1.51	− 5.56		
Lower Peach Tree	31 50	87 33	1857.33	− 6.04	+1.29	− 4.75		
Florence	34 47	87 42	1881.68	− 4.63	....	− 4.52		
Indian Mountain	34 02	85 26	1875.65	− 4.18	+0.52	− 3.66		
Decatur	34 37	86 59	1881.66	− 5.17	+0.19	− 4.98		
ALABAMA, PART 2.								
Cahaba	32 18	87 10	1860.3	− 6.17	+1.20	− 4.97	Scott	MS.
Tuscaloosa	33 12	87 40	1875.44	− 6.08	+0.55	− 5.53	Poole	Nat. Acad. Sc.
Mobile Point Light	30 14	88 01	1843.5	− 6.93	+1.52	− 5.41	Powell	U. S. N. Rep. 1840.
Eufaula	31 54	85 08	1881.7	− 4.20	+0.19	− 4.01	Brown	MS.
Montgomery	32 23	86 18	1875.40	− 4.65	+0.55	− 4.10	Poole	Nat. Acad. Sc.
Evergreen	31 26	87 05	1875.40	− 5.53	+0.56	− 4.97	....do	do.
Mobile	30 42	88 03	1875.40	− 6.12	....	− 5.56	....do	do.
Birmingham	33 32	86 53	1875.44	− 4.44	+0.55	− 3.89	....do	do.
Selma	32 25	87 05	1875.44	− 4.54	+0.55	− 3.99	....do	do.
Opelika	32 40	85 25	1875.44	− 4.53	+0.55	− 3.98	....do	do.
Madison	34 41	86 48	1875.41	− 5.19	+0.53	− 4.66	Hilgard	do.
ALASKA, PART 1.								
Sitka, Japonski Island	57 03	135 20	1881.70	−29.19	....	−28.84		
Saint Paul, Kadiak	57 48	152 21	1880.53	−25.15	....	−24.42		
Unalashka	53 53	166 32	1880.57	−18.63	....	−18.80		
Chichagoff Harbor	52 56	186 48	1873.48	− 7.72	+0.44	− 7.28		
Kyska Harbor	51 59	182 30	1873.55	−11.11	+0.44	−10.67		
Amchitka	51 24	180 48	1873.58	− 7.28	+0.43	− 6.85		
Adakh Island	51 49	176 52	1873.61	−13.87	+0.40	−13.47		
Atka Island	52 11	174 15	1873.65	−16.96	+0.39	−16.57		
Humboldt Harbor	55 19	160 31	1880.55	−20.28	+0.32	−19.96		
Lituya Bay	58 37	137 40	1874.37	−30.05	+0.80	−29.25		
Port Mulgrave	59 34	139 46	1880.48	−30.00	....	−29.06		
Port Etches	60 21	146 38	1874.41	−29.16	....	−27.21		
Chirikoff Island	55 48	155 43	1874.45	−23.02	+0.85	−22.17		
Semidi Island	56 05	156 39	1874.45	−22.95	+0.85	−22.10		
Chiachi Island	55 52	159 05	1874.48	−21.93	+0.72	−21.21		
Chignik Bay	56 19	158 24	1874.46	−22.03	+0.75	−21.28		
Little Koniushi Island	55 03	159 23	1880.54	−21.42	+0.32	−21.10		
Saint Paul Island	57 07	170 19	1880.60	−17.65	+0.25	−17.40		
Nunivak Island	60 25	166 08	1874.58	−21.56	+1.06	−20.50		
Hagmeister Island	58 48	160 50	1874.60	−22.88	+1.08	−21.80		
Port Moeller	55 55	160 35	1874.61	−21.37	+0.72	−20.65		
Kasaan Bay	55 30	132 19	1880.35	−27.80	+0.10	−27.70		
Port Althorp	58 12	136 24	1880.46	−32.26	+0.25	−32.01		
Coal Point	59 36	151 24	1880.50	−25.81	+0.65	−25.16		
Dangerous Cape	59 24	151 53	1880.51	−24.54	+0.65	−23.89		
Dolgoi Island	55 03	161 43	1880.56	−17.98	+0.27	−17.71		
Belkoffsky Settlement	55 05	162 00	1880.56	−21.43	+0.27	−21.16		
Near Cape Lisburne	68 53	166 06	1880.64	−25.71	+0.78	−24.93		
Near Icy Cape	70 13	162 15	1880.65	−30.10	+0.78	−29.32		
Chamisso Harbor	66 13	161 49	1880.66	−26.82	....	−26.00		
Point Spencer, Port Clarence	65 16	166 51	1880.69	−22.75	....	−22.00		
Cove Point	53 24	167 30	1880.75	−16.26	+0.14	−16.12		
Shukan	56 09	133 38	1881.62	−30.05	+0.08	−29.97		

* See also Tillo's comparative chart: Carte des lignes d'égale déclinaison magnétique, construite pour l'époque 1880.0; par Alexis de Tillo, colonel d'état-major Russe. Avec le but de montrer la différence entre les cartes isogoniques de l'an 1880.0, des Amirautés Allemande et Anglaise, 1881.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
ALASKA, PART 1—Continued.	° '	° '		°	°	°		
Fort Wrangell	56 28	132 23	1881.64	−29.28	+0.08	−29.20		
Howcan Mission	54 50	132 50	1881.67	−27.06	+0.08	−26.98		
ALASKA, PART 2.								
Fort Yukon	66 34	145 18	1869.62	−36.54			Raymond	MS.
Point Barrow (Plover Point)	71 21	156 17	1854.5	−41.00			Maguire	Phil. Trans. Roy. Soc., 1872.
Croyalgu Island	54 17	164 47	1826.5	−20.83	+2.90	−17.93	Beechey	do.
Amok Island	55 27	164 02	1827.5	−21.25	+2.90	−18.35	Lütke	do.
Cape Black	58 43	162 05	1827.5	−25.17	+2.80	−22.37	do	do.
Wrangell Harbor	56 59	157 57	1827.5	−24.00	+2.20	−21.80	do	do.
Cape Suwaroff	58 42	157 00	1827.5	−26.25	+2.80	−23.45	do	do.
Norton Sound	63 28	161 42	1827.5	−30.50	+4.70	−25.80	do	do.
Cape Good Hope	66 03	164 30	1826.5	−29.47	+4.45	−25.02	Beechey	do.
Cape Krusenstern	67 11	163 37	1826.5	−30.20	+4.45	−25.75	do	do.
Cape Deceit	66 06	162 36	1826.5	−30.30	+4.45	−25.85	do	do.
Point Demarcation	69 41	141 00	1837.54	−48.38			Simpson	do.
Wainwright Inlet	70 37	160 03	1849.5	−36.68			Kellett	do.
Boat Extreme	71 02	154 23	1837.58	−42.60			Simpson	do.
Point Comfort	70 43	152 14	1837.57	−43.13			do	do.
On ice, northwest of Anxiety Point.	70 31	148 34	1850.5	−44.62			McClure	do.
Foggy Island	70 16	147 38	1825.5	−43.25			Franklin	do.
Point Anxiety	70 10	147 30	1837.55	−45.00			Simpson	do.
Bailey's Harbor	55 09	162 07	1879.5	−21.13	+0.32	−20.81	Bailey	Rep. on Alaska.
Fort Michael, Norton Sound	63 48	161 00	1874.5	−23.00	+1.70	−21.30	Turner	Sig. Off. Rep., 1876.
ARIZONA TERRITORY, PART 1.								
ARIZONA TERRITORY, PART 2.								
San Bernardino	31 20	109 14	1855.3	−11.75	−0.50	−12.25	Emory	Mex. Bound. Sur., 1853.
Santa Cruz River	31 18	110 31	1855.4	−11.75	−0.55	−12.30	do	do.
Los Nogales	31 21	110 51	1855.5	−12.22	−0.55	−12.77	do	do.
San Pedro	32 59	110 40	1851.5	−12.42	−0.60	−13.02	do	do.
Pimos Villages	33 07	111 44	1851.5	−12.87	−0.65	−13.52	do	do.
Gila Junction	32 43	114 33	1851.5	−12.83	−0.80	−13.63	do	do.
Camp Apache	33 47	109 57	1871.5	−14.18	0.00	−14.18	Wheeler, Lockwood.	Ch. of Eng's, Rep. 1876.
Cañon Spring	35 45	113 50	1871.5	−14.10	−0.20	−14.30	Lockwood	do.
Big Hills	33 23	109 55	1873.5	−13.10	0.00	−13.10	Tillman	do.
Bouchés Fork	34 33	110 04	1871.5	−14.86	0.00	−14.86	Lockwood	do.
Escudilla Peak	33 59	109 06	1873.5	−12.55	0.00	−12.55	Hoxie	do.
Green Springs	36 11	111 17	1873.5	−15.47	0.00	−15.47	do	do.
Limestone Water Pocket	36 32	111 32	1873.5	−15.26	0.00	−15.26	do	do.
Moencopie Cañon	36 08	111 08	1873.5	−14.40	0.00	−14.40	do	do.
San Pedro River	32 43	110 34	1873.5	−12.82	−0.20	−13.02	Tillman	do.
Prieto Crossing	33 34	109 55	1873.5	−12.60	0.00	−12.60	do	do.
Pueblo Viejo	32 49	109 37	1873.5	−14.18	0.00	−14.18	do	do.
Rattlesnake Cañon	34 56	112 17	1871.5	−14.70	−0.20	−14.90	Lockwood	do.
Relief Springs	35 09	112 10	1871.5	−14 37	−0.20	−14.57	do	do.
Jacob's Well	35 04	109 14	1853.91	−13.73	0.00	−13.73	Ives	C. S. Rep. 1856.
Navajo Springs	35 06	109 20	1853.91	−13.38	0.00	−13.38	do	do.
Carriso Creek	35 06	109 32	1853.92	−13.90	0.00	−13.90	do	do.
Near Lithodendron Creek	35 02	109 41	1853.92	−13.55	0.00	−13.55	do	do.
Near Rio Puerco of the West	34 58	109 52	1853.92	−14.00	0.00	−14.00	do	do.
Colorado Chiquito	34 53	110 04	1853.93	−13.70	0.00	−13.70	do	do.
do	35 00	110 25	1853.93	−13.67	0.00	−13.67	do	do.
do	35 01	110 30	1853.94	−13.35	0 00	−13.35	do	do.
do	35 12	110 37	1853.95	−13.65	0.00	−13.65	do	do.
do	35 18	110 53	1853.96	−13.70	0.00	−13.70	do	do.
Saroux Spring	35 17	111 39	1853.99	−13.87	−0.25	−14.12	do	do.
Cedar Creek	35 21	112 20	1854.03	−13.82	−0.30	−14.12	do	do.
Pueblo Creek	34 56	112 46	1854.06	−13.98	−0.35	−14.33	do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
ARIZONA TERRITORY, PART 2—Continued.	° ′	° ′		°	°	°		
Williams River	34 59	112 57	1854.06	—14.80	—0.35	—15.15	Ives	C. S. Rep., 1856.
do	35 07	113 13	1854.08	—13.67	—0.40	—14.07	...do	do.
White Cliff Creek	35 08	113 31	1854.09	—14.70	—0.40	—15.10	...do	do.
Big Horse Spring	35 01	113 36	1854.09	—14.30	—0.50	—14.80	...do	do.
Williams River	34 36	113 28	1854.10	—14.03	—0.50	—14.53	...do	do.
do	34 32	113 28	1854.10	—13.97	—0.50	—14.47	...do	do.
do	34 17	113 26	1854.12	—13.40	—0.50	—13.90	...do	do.
do	34 13	113 33	1854.13	—13.68	—0.50	—14.18	...do	do.
Colorado River	34 23	114 06	1854.14	—14.13	—0.50	—14.63	...do	do.
Camp 130	34 36	114 16	1854.15	—13.85	—0.50	—14.35	...do	do.
Camp 132	34 46	114 23	1854.15	—13.60	—0.50	—14.10	...do	do.
Camp 135	34 52	114 32	1854.16	—13.93	—0.50	—14.43	...do	do.
Camp Mojave	35 12	114 36	1875.7	—14.75	—0.15	—14.90	Bergland	Ch. of Eng's. Rep. 1876.
Colorado River	34 45	114 24	1854.5	—13.80	—0.50	—14.30	Ives, Whipple	Phil. Trans. Roy. Soc., 1874.
Fort Grant	32 54	110 40	1873.5	—13.82	—0.18	—14.00	Russell	Ch. of Eng's. Rep. 1879.
Fort Bowie	32 10	109 50	1873.5	—13.80	—0.15	—13.95	...do	do.
ARKANSAS, PART 1.								
ARKANSAS, PART 2.								
Little Rock	34 46	92 15	1875.38	— 8.18	+0.53	— 7.65	Hilgard	Nat. Acad. Sc.
Williams Landing	34 50	92 30	1870.3	— 7.27	+0.78	— 6.49	Abert	MS.
Isaac Creek	34 04	92 39	1870.3	— 7.50	+0.78	— 6.72	...do	MS.
Stout's Landing	35 07	92 50	1870.3	— 7.73	+0.78	— 6.95	...do	MS.
Hog Thief Bend	35 17	93 03	1870.3	— 8.32	+0.78	— 7.54	...do	MS.
Delaware Creek	35 17	3 15	1870.3	— 8.42	+0.78	— 7.64	...do	MS.
Shoal Creek	35 20	93 25	1870.3	— 8.50	+0.78	— 7.72	...do	MS.
Profile Rock	35 23	93 31	1870.3	— 8.57	+0.78	— 7.79	...do	MS.
Roseville	35 22	93 47	1870.3	— 8.83	+0.78	— 8.05	...do	MS.
Earn's Landing	35 27	94 04	1870.3	— 9.00	+0.78	— 8.22	...do	MS.
Fort Smith	35 23	94 30	1878.5	— 8.83	+0.36	— 8.47	Sutter, Wellman	Ch. of Eng's, Rep. 1878.
Washita or Saline River	34 00	92 00	1804.5	— 8.33	+2.45	— 5.88	Dunbar	Sill. Jour., vol. 34, 1838.
Buffalo, White River	36 12	92 30	1878.5	— 8.00	+0.36	— 7.64	Sutter, Wellman	Ch. of Eng's, Rep. 1878.
Scanlan's Landing	35 02	90 16	1878.06	— 6.95	+0.39	— 6.56	Powell	do.
CALIFORNIA, PART 1.								
Point Conception	34 27	120 27	1872.93	—14.86	—0.30	—15.16		
Point Pinos	36 38	121 56	1873.66	—15.92	—0.26	—16.18		
San Diego, La Playa	32 42	117 15	1881.26	—13.46	....	—13.60		
San Francisco, Présidio	37 48	122 27	1881.70	—16.30	....	—16.56		
Bucksport	40 47	124 12	1853.55	—17.11	—0.90	—18.01		
San Pedro	33 44	118 17	1881.28	—14.45	—0.10	—14.55		
San Luis Obispo	35 11	120 44	1881.29	—15.61	—0.08	—15.69		
Humboldt	40 45	124 13	1854.33	—17.08	—0.86	—17.94		
Monterey	36 36	121 54	1881.30	—15.90	....	—16.03		
Ross Mountain	38 30	123 07	1860.04	—16.39	—0.43	—16.82		
Tomales Bay	38 11	122 57	1857.10	—16.01	—0.53	—16.54		
Bodega	38 18	123 00	1860.56	—16.31	—0.41	—16.72		
Santa Barbara	34 25	119 42	1881.28	—14.86	—0.09	—14.95		
San Buenaventura	34 16	119 16	1870.05	—15.13	—0.42	—15.55		
Dominguez Hill	33 52	118 14	1870.18	—15.35	—0.42	—15.77		
Punta Arena	38 55	123 44	1870.40	—17.63	—0.41	—18.04		
San Diego	32 43	117 10	1871.41	—14.78	—0.38	—15.16		
Eureka	40 48	124 10	1871.58	—18.71	—0.30	—19.01		
Lake Tahoe	38 55	120 05	1879.72	—13.80	—0.03	—16.83		
Table Mountain	37 55	122 36	1879.84	—16.00	—0.04	—16.04		
Monticello	38 40	122 11	1880.77	—17.21	—0.03	—17.24		
Sacramento	38 36	121 28	1881.27	—15.86	—0.03	—15.89		
Blue Cañon	39 15	120 47	1881.27	—15.64	—0.02	—15.66		
Vaca	38 22	122 05	1880.89	—17.19	—0.03	—17.22		
CALIFORNIA, PART 2.								
San Isabel	33 09	116 38	1852.5	—12.57	—1.00	—13.57	Emory	Mex. Bound. Sur., 1853.
Camp Riley	32 36	117 05	1849.5	—12.95	—1.10	—14.05	...do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
CALIFORNIA, PART 2—Continued.	° ′	° ′		°	°	°		
Shelter Cove	40 03	124 09	1792.30	—15.00	—3.72	—18.72	Vancouver	Hansteen's Erdmag.
Trinidad	41 07	126 36	1841.5	—16.00	—1.42	—17.42	Duflot de Mofras	Expl. de Orégon.
Desert Springs	35 18	117 57	1871.5	—15.52	—0.38	—15.90	Lockwood	Ch. of Eng's, Rep. 1876.
Saratoga Springs	35 41	116 10	1871.5	—15.09	—0.38	—15.47	.. do	do.
Station A, Penamint Valley	36 05	117 14	1875.5	—15.18	—0.22	—15.40	Birnie	do.
Cerro Gordo Landing	36 28	117 51	1875.5	—15.31	—0.22	—15.53	....do	do.
Forks, Los Angeles and Caliente roads.	35 08	118 09	1875.5	—14.80	—0.23	—15.03	....do	do.
Old Fort Tejon	34 52	118 55	1875.5	—14.91	—0.24	—15.15	Wheeler	do.
Furnace Creek	36 26	116 49	1875.5	—15.69	—0.11	—15.80	Birnie	do.
Tehachipai Valley	35 07	118 28	1875.5	—14.20	—0.24	—14.44	Whipple	do.
Wild Rose Spring	36 16	117 12	1875.5	—15.32	—0.13	—15.45	Birnie	do.
Pai-ute Creek	35 06	114 54	1854.17	—14.28	—0.50	—14.78	Ives	C. S. Rep., 1856.
Near Marl Springs	35 11	115 33	1854.18	—13.98	—0.50	—14.48	....do	do.
Soda Lake	35 03	115 59	1854.18	—13.85	—0.50	—14.35	....do	do.
Camp Bidwell	41 52	120 09	1877.5	—17.88	—0.07	—17.95	Symons	Ch. of Eng's, Rep. 1878.
Cisco	39 19	120 33	1877.5	—17.18	—0.04	—17.22	Macomb	do.
New York of the Pacific	38 03	121 49	1850.0	—15.70	—0.76	—16.46		Charts by Ringold
Suisun City	38 11	121 37	1850.0	—15.68	—0.76	—16.44		do.
Barber's	38 19	121 30	1850.0	—16.33	—0.76	—17.09		do.
Fort Yuma	32 44	114 36	1876.2	—13.77	—0.15	—13.92	Bergland	Ch. of Eng's, Rep. 1876
Fort Rumantsoff	38 19	122 43	1818.7	—16.50	—2.20	—18.70	Golovnin	Voyage, St. Petersburg, 1822, vol. 2.
COLORADO, PART 1.								
Denver	39 45	105 00	1878.68	—14.67	....	—14.48		
Colorado Springs	38 50	104 49	1878.65	—14.79	+0.15	—14.64		
West Las Animas	38 04	103 01	1878.62	—13.46	+0.15	—13.31		
North Pueblo	38 18	104 37	1878.64	—13.67	+0.15	—13.52		
Greeley	40 26	104 40	1878.69	—14.56	+0.15	—14.41		
COLORADO, PART 2.								
La Veta Creek	37 32	105 03	1873.5	—14.12	+0.28	—13.84	Marshall	Ch. of Eng's, Rep. 1876.
Arkansas River	38 28	105 51	1873.5	—14.68	+0.28	—14.40	....do	do.
Buffalo Slough	38 48	105 42	1873.5	—14.41	+0.28	—14.13	....do	do.
Cucharas River	37 30	105 01	1873.5	—14.01	+0.28	—13.73	... do	do.
Currant Creek	38 40	105 30	1873.5	—14.40	+0.28	—14.12	....do	do.
Diana Creek	37 42	107 48	1874.5	—14.53	+0.20	—14.33	....do	do.
Dolores River	37 47	107 57	1874.5	—14.16	+0.20	—13.96	Whipple	do.
do	37 31	108 04	1874.5	—14.00	+0.20	—13.80	....do	do.
Fort Garland	37 26	105 26	1873.5	—14.12	+0.28	—13.84	Marshall	do.
Hayden Creek	38 20	105 47	1874.5	—14.09	+0.26	—13.83	....do	do.
High Creek	38 41	105 18	1873.5	—15.01	+0.28	—14.73	....do	do.
La Loma	37 41	106 14	1873.5	—14.88	+0.25	—14.63	....do	do.
Los Pinos Indian Agency	38 12	106 49	1874.5	—14.83	+0.22	—14.61	....do	do.
Purgatoire River	37 18	104 19	1873.5	—14.38	+0.28	—14.10	....do	do.
Rio Grande	37 45	107 27	1874.5	—14.83	+0.20	—14.63	... do	do.
Saguache, Craig's ranch	38 02	106 37	1873.5	—14.58	+0.25	—14.33	....do	do.
San Juan River	37 26	106 47	1874.5	—15.02	+0.22	—14.80	....do	do.
San Juan River, head of East Fork.	37 23	106 46	1874.5	—14.97	+0.22	—14.75	....do	do.
San Juan Mines	37 50	107 35	1873 5	—14.64	+0.25	—14.39	....do	do.
Simpson's Peak Camp	37 41	107 22	1874.5	—14.50	+0.22	—14.28	....do	do.
Wet Mountain Valley	38 02	105 25	1873.5	—14.33	+0.28	—14.05	....do	do.
Fort Lyon	38 08	102 50	1866.5	—14.50	+0.48	—14.02	Prince	MS.
North Boundary of Colorado	41 00	105 00	1866.5	—15.25	+0.48	—14.77	....do	MS.
East Boundary of Colorado	39 59	102 03	1872.82	—14.17	+0.30	—13.87	Major	Gen'l Land Off. Rep.
East Boundary, 3d Station	39 57	102 03	1872.8	—14.00	+0.30	—13.70	....do	do.
East Boundary, 6th Station	39 54	102 03	1872.8	—14.00	+0.30	—13.70	....do	do.
East Boundary, 7th Station	39 52	102 03	1872.8	—14.08	+0.30	—13.78	....do	do.
East Boundary, 40th Station	39 26	102 03	1872.8	—13.58	+0.30	—13.28	....do	do.
East Boundary, 68th Station	39 01	102 03	1872.8	—13.50	+0.30	—13.20	....do	do.
East Boundary, 111th Station	38 25	102 03	1872.8	—13.50	+0.30	—13.20	....do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
COLORADO, PART 2—Continued.	° ′	° ′		°	°	°		
East Boundary, 123d Station	38 15	102 03	1872.9	−13.17	+0.30	−12.87	Major	Gen. Land. Off. Rep.
East Boundary, 130th Station	38 08	102 03	1872.9	−13.08	+0.30	−12.78	...do	do.
East Boundary, 154th Station	37 47	102 03	1872.9	−13.00	+0.30	−12.70	...do	do.
East Boundary, 173d Station	37 30	102 03	1872.9	−12.50	+0.30	−12.20	...do	do.
La Costilla	37 00	105 30	1872.13	−14.43	+0.33	−14.10	Moore	MS.
La Junta, near Eclipse Station	37 59	103 33	1878.58	−14.06	+0.15	−13.91	Thorpe	Proc. Roy. Soc., 1880.
CONNECTICUT, PART 1.								
Tashua	41 16	73 15	1863.69	+ 8.04	+1.46	+ 9.50		
New Haven (Yale)	41 18	72 56	1844.66	+ 5.75	+3.44	+ 9.19		
Stamford	41 04	73 32	1844.70	+ 6.60	+2.40	+ 9.00		
Norwalk	41 07	73 25	1844.70	+ 6.82	+2.53	+ 9.35		
Stonington	41 20	71 54	1845.60	+ 7.64	+2.44	+10.08		
New London	41 18	72 00	1845.62	+ 7.49	+2.44	+ 9.93		
Saybrook	41 16	72 21	1845.63	+ 6.83	+2.51	+ 9.34		
Sachem's Head	41 17	72 44	1845.64	+ 6.25	+2.63	+ 8.88		
New Haven (Pavilion)	41 18	72 55	1848.61	+ 6.63	+2.56	+ 9.19		
Bridgeport	41 10	73 11	1845.71	+ 6.32	+2.63	+ 8.95		
Milford	41 14	73 04	1845.72	+ 6.64	+2.63	+ 9.27		
Black Rock	41 09	73 13	1845.72	+ 6.89	+2.63	+ 9.52		
Fort Wooster	41 17	72 54	1848.64	+ 7.42	+2.45	+ 9.87		
New Haven, Oyster Point	41 17	72 56	1855.63	+ 7.04	+2.15	+ 9.19		
Hartford	41 46	72 40	1879.56	+ 8.57	+0.35	+ 8.92		
Bald Hill	41 58	72 12	1861.71	+ 8.84	+1.44	+10.28		
Box Hill	41 48	72 27	1861.79	+ 8.51	+1.44	+ 9.95		
Sandford	41 28	72 57	1862.77	+ 7.03	+1,52	+ 8.55		
Ivy	41 52	73 14	1863.58	+ 8.43	+1.46	+ 9.89		
Wooster	41 21	73 29	1864.59	+ 7.63	+1.39	+ 9.02		
CONNECTICUT, PART 2.								
Pomfret	41 52	71 57	1810.5	+ 5.08	+4.23	+ 9.31	Miller	Sill. Jour., vol. 34, 1838.
Hebron	41 38	72 18	1835.5	+ 6.00	+3.09	+ 9.09	Gillet	do.
Danbury	41 22	73 23	1810.5	+ 5.68	+4.43	+10.11	Miller	do.
Lyme	41 18	72 17	1810.5	+ 4.50	+4.43	+ 8.93	...do	do.
DAKOTA TERRITORY, PART 1.								
Pembina	48 59	97 14	1880.69	−12.61	+0.08	−12.53		
Jamestown	46 53	98 45	1880.70	−13.51	+0.08	−13.43		
Bismarck	46 46	100 38	1880.73	−15.83	+0.08	−15.75		
Yankton	42 54	97 28	1880.77	−12.07	+0.18	−11.89		
DAKOTA TERRITORY, PART 2.								
Northwest boundary, Woodend	49 00	103 00	1873.6	−18.00	+0.15	−17.85	Twining	N. W. Bound. Surv., 1878.
Northwest boundary	49 00	102 00	1873.6	−18.00	+0.15	−17.85	...do	do.
Northwest boundary, near Bear Butte.	49 00	100 30	1873.6	−17.25	+0.15	−17.10	... do	do.
Northwest boundary	49 00	103 30	1873.7	−18.13	+0.15	−17.98	...do	do.
Northwest boundary, near Pembina Mountains.	49 00	98 00	1872.5	−15.17	+0.18	−14.99	...do	do.
Northwest boundary	49 00	97 40	1872.5	−15.00	+0.18	−14.82	...do	do.
do	49 00	98 10	1872.5	−15.50	+0.18	−15.32	...do	do.
do	49 00	98 28	1872.5	−15.50	+0.18	−15.32	...do	do.
do	49 00	98 33	1872.5	−15.58	+0.18	−15.40	...do	do.
do	49 00	98 45	1872.6	−15.25	+0.18	−15.07	...do	do.
do	49 00	98 55	1872.6	−15.67	+0.18	−15.49	...do	do.
do	49 00	99 05	1872.6	−15.92	+0.18	−15.74	...do	do.
do	49 00	100 25	1873.6	−16.67	+0.15	−16.52	...do	do.
do	49 00	100 40	1873.6	−17.17	+0.15	−17.02	...do	do.
do	49 00	101 10	1873.6	−17.75	+0.15	−17.60	...do	do.
do	49 00	102 15	1873.6	−18.18	+0.15	−18.03	...do	do.
Fort Pierre	44 25	100 24	1860.00	−14.75	+0.40	−14.35		MS. by Raynolds.
Cheyenne River	44 35	101 25	1859.5	−14.50	+0.40	−14.10		do.
.ed Earth Creek	44 35	103 54	1859.5	−17.00	+0.40	−16.60		do.
Near Fort Berthold	47 28	101 50	1860.5	−18.97	+0.35	−18.62		do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
DAKOTA TER., PART 2—Cont'd.	° ′	° ′		°	°	°		
Little Moreau River	45 18	101 02	1860.5	−16.50	+0.37	−16.13	....	MS. by Raynolds.
White River	43 45	99 45	1860.5	−14.83	+0.40	−14.43	....	do.
Fort Col. Fur Company	45 39	96 34	1823.5	−12.48			Long's expedition.	Silliman's Journal, 1838.
Encampment on Saint Peter River	44 41	97 00	1823.5	−12.35	....	....	....do	do.
Cold Springs	44 09	104 02	1877.60	−15.69	+0.12	−15.57	Stanton	Chief Engineer's Rep., 1878.
Spearfish Creek	44 30	103 51	1877.63	−15.44	+0.12	−15.32	....do	do.
Spring Creek	43 57	103 12	1877.77	−16.36	+0.12	−16.24	....do	do.
Oak Grove	44 27	103 36	1877.77	−16.06	+0.12	−15.94	....do	do.
French Creek	43 46	103 34	1877.79	−15.36	+0.12	−15.24	....do	do.
South Cheyenne River	43 18	103 50	1877.80	−15.50	+0.12	−15.38	....do	do.
DELAWARE, PART 1.								
Cape Henlopen	38 47	75 05	1856.65	+ 3.06	+1.61	+ 4.67		
Wilmington	39 47	75 32	1875.55	+ 3.74	+0.68	+ 4.42		
Sawyer	39 42	75 34	1846.42	+ 2.80	+2.52	+ 5.32		
Fort Delaware	39 35	75 34	1846.45	+ 3.28	+2.52	+ 5.80		
Bombay Hook	39 22	75 31	1846.46	+ 3.31	+2.52	+ 5.83		
Lewis Landing	38 49	75 12	1846.50	+ 2.75	+2.32	+ 5.07		
Dagsborough	38 35	75 16	1856.66	+ 2.68	+1.71	+ 4.39		
DELAWARE, PART 2.								
Delaware City	39 35	75 21	1842.5	+ 3.50	+2.73	+ 6.23	Barnett	Phil. Trans. Roy. Soc., 1874.
FLORIDA, PART 1.								
Sand Key	24 27	81 53	1849.64	− 5.48	+2.42	− 3.06		
Cape Florida	25 40	80 10	1850.15	− 4.42	+2.39	− 2.03		
Depot Key, Cedar Keys	29 08	83 02	1852.20	− 5.34	+1.86	− 3.48		
Saint Mark's Light	30 04	84 11	1852.25	− 5.49	+1.86	− 3.63		
Dog Island Light	29 47	84 40	1853.25	− 5.85	+1.82	− 4.03		
Saint George's Island	29 37	85 06	1853.26	− 6.04	+1.66	− 4.38		
Cape Saint Blas	29 40	85 22	1854.08	− 6.11	+1.63	− 4.48		
Hurricane Island	30 04	85 39	1854.10	− 6.20	+1.63	− 4.57		
Fernandina	30 40	81 27	1879.10	− 2.50	+0.36	− 2.14		
Cape Sable	25 08	81 02	1855.4	− 5.38	+2.06	− 3.32		
Pensacola	30 25	87 12	1861.02	− 6.70	+1.17	− 5.53		
Apalachicola	29 43	84 59	1860.09	− 6.20	+1.39	− 4.81		
Key West	24 33	81 48	1879.23	− 3.56	....	− 3.12		
Punta Rasa	26 29	82 01	1866.49	− 4.02	+1.31	− 2.71		
Turkey Creek	28 04	80 35	1878.38	− 3.15	+0.41	− 2.74		
Bird Key, Dry Tortugas	24 37	82 54	1880.04	− 3.71	+0.35	− 3.36		
Jacksonville	30 21	81 40	1880.09	− 2.34	+0.30	− 2.04		
Saint Augustine	29 54	81 19	1880.11	− 2.42	+0.30	− 2.12		
Enterprise	28 53	81 14	1880.13	− 2.77	+0.31	− 2.46		
Eau Gallie	28 09	80 37	1880.15	− 2.00	+0.31	− 1.69		
Saint Lucie	27 29	80 15	1880.17	− 2.42	+0.32	− 2.10		
Fort Jupiter	26 54	80 05	1880.18	− 2.84	+0.32	− 2.52		
FLORIDA, PART 2.								
Daytona	29 08	80 58	1876.20	− 3.24	+0.55	− 2.69	Rogers	MS.
Titusville	28 36	80 48	1879.68	− 2.08	+0.34	− 1.74	Le Baron	MS.
Tallahassee	30 26	84 17	1875.38	− 3.70	+0.54	− 3.16	Poole	National Acad. of Sciences.
Egmont Key, Tampa Bay	27 36	82 05	1843.5	− 5.42	+2.35	− 3.07	Powell	U. S. Naval Report, 1843.
Saint Joseph's Bay Light	29 52	85 23	1843.5	− 6.40	+1.52	− 4.88	....do	do.
Off west end Florida Reef	24 15	82 40	1818.5	− 6.55	+3.60	− 2.95	Livingston	Becq. Traité du Mag. 1846.
Lake City	30 11	82 37	1875.37	− 3.34	+0.59	− 2.75	Poole	National Acad. of Sciences.
Saint Mark's	30 08	84 11	1875.38	− 4.50	+0.59	− 3.91	....do	do.
GEORGIA, PART 1.								
Savannah	32 05	81 05	1874.19	− 2.28	+0.68	− 1.60		
Tybee Light	32 02	80 51	1870.38	− 2.34	+0.86	− 1.48		
Butler	31 18	81 21	1872.20	− 2.72	+0.70	− 2.02		
Middle Base	33 54	84 17	1873.12	− 3.58	+0.65	− 2.93		
Kenesaw	33 59	84 35	1873.58	− 4.72	+0.63	− 4.09		
Sweat	34 04	84 27	1873.77	− 5.61	+0.61	− 5.00		

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
GEORGIA, PART 1—Continued.	° ′	° ′		°	°	°		
Sawnee	34 14	84 10	1873.83	— 2.92	+0.61	— 2.31		
Cumming	34 12	84 08	1873.86	— 3.22	+0.61	— 2.61		
Carnes	34 00	85 01	1873.97	— 4.09	+0.60	— 3.49		
Grassy	34 29	84 20	1874.56	— 3.60	+0.57	— 3.03		
Pine Log	34 19	84 38	1874.61	— 4.00	+0.57	— 3.43		
Skitt	34 30	83 43	1874.63	— 2.59	+0.57	— 2.02		
Currahee	34 32	83 23	1874.80	— 2.80	+0.56	— 2.24		
Academy	33 58	84 00	1874.94	— 3.41	+0.55	— 2.86		
Lavender	34 19	85 17	1874.95	— 3.98	+0.55	— 3.43		
Johns	34 37	85 06	1875.47	— 3.95	+0.52	— 3.43		
Dupont, or Lawton	30 58	82 47	1880.08	— 2.43	+0.28	— 2.15		
Skiddeway, N. Base	31 56	81 02	1856.3	— 3.42	+1.69	— 1.73		
GEORGIA, PART 2.								
Athens	33 57	83 25	1837.5	— 4.52	+2.29	— 2.23	McCay	Sill. Jour., 1838.
Milledgeville	33 04	83 10	1875.46	— 3.06	+0.52	— 2.54	Poole	Nat. Acad. Sc.
Toccoa Falls	34 36	83 20	1837.5	— 5.00	+2.29	— 2.71	Geol. Survey	Sill. Jour., 1840.
Carnesville	34 25	83 25	1837.5	— 5.02	+2.29	— 2.73	....do	do.
Elberton	34 06	82 59	1837.5	— 4.55	+2.29	— 2.26	....do	do.
Lawrenceville	33 58	84 10	1839.5	— 5.00	+2.22	— 2.78	....do	do.
Goshen	33 52	82 40	1837.5	— 5.15	+2.29	— 2.86	....do	do.
Monroe	33 51	83 53	1838.5	— 5.17	+2.25	— 2.92	....do	do.
Lincolnton	33 46	82 38	1837.5	— 5.15	+2.29	— 2.86	....do	do.
Madison	33 34	83 40	1838.5	— 4.48	+2.25	— 2.23	....do	do.
Applington	33 32	82 27	1837.5	— 5.00	+2.43	— 2.57	....do	do.
Augusta	33 26	82 01	1837.5	— 5.07	+2.72	— 2.35	....do	do.
Eatonton	33 21	83 34	1838.5	— 4.53	+2.25	— 2.28	....do	do.
Waynesborough	33 03	82 09	1837.5	— 5.07	+2.72	— 2.35	....do	do.
Sandersville	32 57	82 59	1838.5	— 5.45	+2.25	— 3.20	....do	do.
Mill Haven	32 56	81 47	1837.5	— 5.07	+2.72	— 2.35	....do	do.
Black Creek	32 39	81 20	1837.5	— 5.07	+2.72	— 2.35	....do	do.
Jacksonborough	32 49	81 43	1837.5	— 4.92	+2.72	— 2.20	....do	do.
Birdsville	32 48	82 13	1837.5	— 5.02	+2.72	— 2.30	....do	do.
Swainsborough	32 39	82 30	1838.5	— 5.07	+2.67	— 2.40	....do	do.
Columbus	32 28	85 10	1839.5	— 5.50	+2.22	— 3.28	....do	co.
Springfield	32 21	81 30	1837.5	— 5.08	+2.72	— 2.36	....do	do.
Lumpkin	32 09	84 55	1839.5	— 5.45	+2.08	— 3.37	....do	do.
Bryan, court-house	32 02	81 32	1838.5	— 5.08	+2.67	— 2.41	....do	do.
Cuthbert	31 49	85 02	1839.5	— 5.50	+2.08	— 3.42	....do	do.
Liberty, court-house	31 48	81 37	1838.5	— 5.08	+2.67	— 2.41	....do	do.
Fort Gaines	31 38	85 19	1839.5	— 5.52	+2.08	— 3.44	....do	do.
Darien	31 26	81 37	1838.5	— 5.08	+2.67	— 2.41	....do	do.
Bainbridge	30 55	84 46	1839.5	— 5.50	+2.08	— 3.42	....do	do.
Macon	32 50	83 38	1875.45	— 3.48	+0.52	— 2.96	Poole	Nat. Acad. Sc
Lumber City	31 57	82 45	1875.46	— 3.18	+0.52	— 2.66	....do	do.
Millen	32 50	81 50	1875.47	— 2.62	+0.52	— 2.10	....do	do.
IDAHO TERRITORY, PART 1.								
Siniaquoteen	48 10	116 45	1881.67	—22.48	+0.03	—22.45		
Lake Pend d'Oreille, steamboat Landing.	47 58	116 30	1881.70	—22.09	+0.03	—22.06		
Lewiston	46 28	117 05	1881.71	—21.44	0.00	—21.44		
IDAHO TERRITORY, PART 2.								
Pack River	48 22	116 28	1861.50	—22.85	—0.20	—23.05	Haig	Phil. Trans. Roy. Soc., 1864.
Chelemta River	48 41	116 19	1861.50	—22.18	—0.20	—22.38	....do	do.
Sohon Pass	47 27	115 43	1860.5	—20.62	—0.20	—20.82	Mullan	Stone's Mag. Var. in U. S., 1878.
Boundary Station	49 00	116 33	1860.5	—22.62	—0.20	—22.82	Harris	N. W. Bound. MS. chart.
Cœur d'Alene Mission	47 33	116 21	1860.5	—20.90	—0.20	—21.10	Mullan	Stone's Mag. Var.
Hot Springs	43 23	116 18	1859.56	—17.83	—0.20	—18.03	Dixon	Sen. Pub. Doc., vol. 9, 1859–'60.
Rattlesnake Meadows	42 56	115 06	1859.58	—17.00	—0.20	—17.20	....do	do.
Salmon River Falls	42 42	114 39	1859.58	—17.18	—0.20	—17.38	....do	do.
Raft Creek	42 36	113 08	1859.59	—16.75	—0.15	—16.90	....do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
IDAHO TERRITORY, PART 2—Continued.	° ′	° ′		°	°	°		
Little Cañon of Smoky Creek	42 47	111 01	1858.68	—19.20	—0.12	—19.32	Wagner	
Land survey, stations	46 17	116 22	1867.5	—20.32	—0.15	—20.47	Chart by Cartee	MS.
do	45 44	116 22	1867.5	—20.94	—0.15	—21.09	....do	MS.
do	45 14	116 22	1867.5	—21.17	—0.15	—21.32	....do	MS.
do	44 45	116 22	1867.5	—19.17	—0.15	—19.32	....do	MS.
do	44 10	116 22	1867.5	—19.12	—0.15	—19.27	....do	MS.
do	43 25	116 22	1867.5	—18.25	—0.15	—18.40	....do	MS.
do	42 00	116 22	1867.5	—18.75	—0.15	—18.90	....do	MS.
do	43 22	116 30	1867.5	—18.45	—0.15	—18.60	....do	MS.
do	43 22	114 17	1867.5	—18.75	—0.12	—18.87	....do	MS.
do	45 50	114 40	1867.5	—19.75	—0.12	—19.87	....do	MS.
Camp 16, mouth of Fall River	44 01	111 30	1872.55	—18.20	0.00	—18.20	Hayden	Geological Surv. Territories 6th Annual Report, 1873.
Henry's Fork	44 19	111 20	1872.59	—18.42	0.00	—18.42	....do	do.
Camp 26	44 30	111 20	1872.60	—19.22	0.00	—19.22	....do	do.
Camp 27, Henry Lake Valley	44 38	111 17	1872.60	—18.73	0.00	—18.73	....do	do.
Snake River, 8 miles below cañon	43 40	111 20	1872.76	—17.98	0.00	—17.98	....do	do.
Camp 52	43 35	111 30	1872.77	—18.00	0.00	—18.00	....do	do.
Willow Creek	43 34	111 42	1872.77	—17.92	0.00	—17.92	....do	do.
Highane's Ranch	43 14	112 26	1872.77	—17.83	0.00	—17.83	....do	do.
Camp 41, northeast of Mount Pisgah.	43 07	111 15	1877.5	—18.33	+0.05	—18.28	Tillman	Ch. of Eng's Rep., 1878.
Camp 43	40 10	111 48	1877.5	—18.72	+0.05	—18.67	....do	do.
Camp 53, southeast of Mount Sedgwick.	42 28	111 47	1877.5	—18.30	+0.05	—18.25	....do	do.
Camp 71	42 38	112 23	1877.5	—18.62	+0.05	—18.57	Young	do.
Camp 77, northwest of Oxford Peak.	42 16	112 05	1877.5	—17.83	+0.05	—17.78	....do	do.
Camp 78, northeast of Elkhorn Peak.	42 23	112 13	1877.5	—17.85	+0.05	—17.80	....do	do.
Camp 80, south of Oxford Settlement.	42 14	112 01	1877.5	—18.35	+0.05	—18.30	....do	do.
Fort Hall	43 09	112 28	1877.5	—18.22	+0.05	—18.17	Birnie	do.
Game Creek	42 46	111 15	1877.5	—18.32	+0.05	—18.27	Tillman	do.
Hawkins' Creek	42 32	112 20	1877.5	—22.78	+0.05	—22.73	Young	do.
Jack Knife Creek	43 02	111 07	1877.5	—18.45	+0.05	—18.40	Tillman	do.
Lane's Fork	42 55	111 18	1877.5	—18.43	+0.05	—18.38	....do	do.
Little Black-pot River	42 57	112 00	1877.5	—18.87	+0.05	—18.82	....do	do.
Malade City	42 11	112 16	1877.5	—17.73	+0.05	—17.68	Birnie	do.
Mink Creek	42 13	111 44	1877.5	—17.85	+0.05	—17.80	Tillman	do.
Port Neuf River	42 47	112 16	1877.5	—18.73	+0.05	—18.68	....do	do.
Robbins' Ford	42 10	111 49	1877.5	—17.80	+0.05	—17.75	....do	do.
Soda Spring Village	42 40	111 35	1877.5	—21.17	+0.05	—21.12	....do	do.
Saint Charles Cañon	42 05	111 32	1877.5	—18.13	+0.05	—18.08	....do	do.
Tincup Run	42 59	111 16	1877.5	—18.53	+0.05	—18.48	....do	do.
Fort Lapway	46 18	116 54	1876.4	—19.75	0.00	—19.75	Miller	Ch. of Eng's Rep., 1876.
ILLINOIS, PART 1.								
Mound City	37 05	89 04	1865.01	— 7.53	+1.11	— 6.42		
Cairo	37 01	89 10	1877.91	— 6.01	+0.39	— 5.62		
Springfield	39 50	89 39	1878.93	— 5.81	+0.33	— 5.48		
ILLINOIS, PART 2.								
Chicago	41 50	87 37	1878.67	— 4.55	+0.51	— 4.04	Thorpe	Proc. Roy. Soc., 1880.
Jacksonville	39 45	90 18	1833.5	— 8.75	+2.72	— 6.03	Sturtevant	Sill. Jour., 1838.
Alton	38 52	90 12	1840.5	— 7.75	+2.38	— 5.37	Loomis	Sill. Jour., 1840.
Cahokia	38 36	90 09	1810.5	— 8.42	+3.40	— 5.02	Mansfield	Sill. Jour., 1838.
Kaskaskia	37 57	89 55	1809.5	— 7.33	+3.40	— 3.93	Public Survey	do.
Public land survey station	41 15	88 32	1821.5	— 8.25	+2.13	— 6.12	....do	Sill. Jour., 1840.
do	41 10	88 32	1838.5	— 7.42	+2.20	— 5.22	....do	do.
do	41 00	88 32	1838.5	— 6.83	+2.20	— 4.63	....do	do.
do	40 50	88 32	1833.5	— 7.72	+2.40	— 5.32	....do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	D1885.0	Observer.	Reference.
ILLINOIS, PART 2—Continued.	° ′	° ′		°	°	°		
Public land survey station	40 30	88 32	1823.5	− 7.50	+2.64	− 4.86	Public Survey	Sill. Jour., 1840.
do	40 20	88 32	1823.5	− 7.67	+2.64	− 5.03	...do	do.
do	40 00	88 32	1822.5	− 7.92	+2.65	− 5.27	...do	do.
do	39 30	88 32	1821.5	− 8.00	+2.82	− 5.18	...do	do.
Galena	42 25	90 26	1876.74	− 9.14	+0.65	− 8.49	Powell	Ch. of Eng's Rep., 1877.
Rockford	42 17	89 07	1876.77	− 5.30	+0.65	− 4.65	...do	do.
Mount Forest	41 45	87 52	1876.66	− 4.59	+0.65	− 3.94	Lockwood	do.
Dunleith	42 28	90 40	1856.80	− 8.58	+1.76	− 6.82	Friesach	Kais. Acad. Wiss., vol. 2, 1858.
Golconda	37 23	88 25	1872.46	− 6.10	+0.69	− 5.41	Hilgard	Nat. Acad., Sc.
Wenona	41 05	89 26	1872.66	− 6.10	+0.93	− 5.17	...do	do.
Macon	39 42	89 10	1872.66	− 5.36	+0.77	− 4.59	...do	do.
Highland	38 45	89 41	1872.67	− 6.57	+0.69	− 5.88	...do	do.
Collinsville	38 39	90 04	1880.38	− 6.51	+0.26	− 6.25	Nipher	Trans. St. Louis Acad. Sc.
Sherwood	42 27	90 37	1839.78	− 9.00	+2.19	− 6.81	Surveyor	Locke's Sur. Min. Lands, 1839-1840.
Rock Island	41 31	90 34	1878.71	− 6.96	+0.50	− 6.46	Powell	Lake Sur. Rep., 1879.
Fulton	41 52	90 12	1844.08	− 8.25	+2.13	− 6.12	Land Survey	MS. by Sprague.
Beardstown	40 00	90 29	1880.60	− 6.72	+0.24	− 6.48	Nipher	Trans. St. Louis Acad. Sc.
New Athens	36 11	89 55	1880.77	− 5.82	+0.24	− 5.58	... do	do.
INDIANA, PART 1.								
New Harmony	38 08	87 50	1880.84	− 5.08	+0.25	− 4.83		
Vincennes	38 42	87 32	1880.83	− 4.38	+0.25	− 4.13		
Indianapolis	39 47	86 08	1880.86	− 2.78	+0.30	− 2.48		
Richmond	39 50	84 50	1880.88	− 2.88	+0.27	− 2.61		
INDIANA, PART 2.								
Michigan City	41 43	86 54	1873.64	− 3.98	+0.86	− 3.12	Lee	MS.
Madison	38 45	85 15	1810.5	− 5.42	+3.05	− 2.37	Mansfield	Sill. Jour., 1838.
South Hanover	38 45	85 23	1837.5	− 4.58	+2.66	− 1.92	Dunn	do.
Falls of the Ohio	38 20	85 40	1810.5	− 5.83	+3.05	− 2.78	Mansfield	do.
Ohio River	38 10	86 30	1810.5	− 6.50	+3.17	− 3.33	...do	do.
Mouth of the Wabash	38 00	88 00	1810.5	− 7.17	+3.28	− 3.89	...do	do.
Logansport	40 45	86 24	1836.5	− 5.58	+2.38	− 3.20	Town plan	Sill. Jour., 1840.
Fort Wayne	41 06	85 03	1874.65	− 2.48	+0.64	− 1.84	Hilgard	Nat. Acad. Sc.
Reynolds	40 45	86 48	1874.65	− 3.50	+0.74	− 2.76	...do	do.
Terre Haute	39 28	87 20	1874.66	− 4.57	+0.72	− 3.85	...do	do.
INDIAN TERRITORY, PART 1.								
Atoka	34 24	96 05	1878.54	− 9.19	+0.30	− 8.89		
Eufaula	35 16	95 33	1878.54	− 9.17	+0.30	− 8.87		
INDIAN TERRITORY, PART 2.								
Wilson Rock	35 19	94 37	1870.3	− 9.33	+0.60	− 8.73	Abert	MS.
Jack Brown's	35 20	94 45	1870.3	− 9.43	+0.60	− 8.83	...do	MS.
Canadian	35 25	95 00	1870.3	− 9.15	+0.60	− 8.55	...do	MS.
Weller's Falls	35 30	95 07	1870.3	− 9.50	+0.60	− 8.90	...do	MS.
Fort Gibson	35 48	95 20	1870.3	− 9.80	+0.60	− 9.20	...do	MS.
Vinita	36 41	95 07	1878.69	− 8.88	+0.30	− 8.58	Nipher	Trans. St. Louis. Acad. Sc.
IOWA, PART 1.								
Des Moines	41 37	93 36	1877.81	− 9.39	+0.40	− 8.99		
Sibley	43 24	95 50	1877.77	−10.84	+0.40	−10.44		
Davenport	41 30	90 38	1877.83	− 7.05	+0.50	− 6.55		
Dubuque	42 30	90 44	1880.81	− 6.76	+0.29	− 6.47		
IOWA, PART 2.								
Cherokee, Eclipse Station	42 46	95 38	1869.60	−11.53	+0.68	−10.85	Blickensderfer	C. S. Rep., 1869.
Engineer Cantonment	41 25	95 44	1819.73	−12.98	....	....	Long's Exp'n	Sill. Jour., 1838.
Near Iowa City	41 40	91 36	1880.46	− 8.83	+0.28	− 8.55	Nipher	Trans. St. Louis. Acad. Sc.
Iowa City	41 39	91 32	1879.50	− 8.06	+0.35	− 7.71	...do	do.
Keokuk	40 25	91 28	1878.58	− 7.58	+0.38	− 7.20	...do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
IOWA, PART 2—Continued.	° ′	° ′		°	°	°		
Lost Grove	41 39	90 09	1839.73	− 8.17	+2.19	− 5.98	Surveyors	Locke's Rep. on Min. Lands. 1839-'40.
Wapsipinecon River	41 44	90 23	1839.73	− 8.42	+2.19	− 6.23	Locke	do.
Iron Ore	41 55	90 40	1839.74	− 7.71	+2.19	− 5.52	....do	do.
Elkford	42 00	90 52	1839.74	− 9.25	+2.19	− 7.06	Surveyors	do.
Small Mill	42 04	91 02	1839.75	− 9.07	+2.19	− 6.88	Locke	do.
Bridge	42 06	91 02	1839.75	− 9.33	+2.19	− 7.14	Surveyors	do.
Makoqueta River	42 14	90 57	1839.75	− 8.75	+2.19	− 6.56	....do	do.
Mill	42 10	90 37	1839.75	− 9.25	+2.19	− 7.06	....do	do.
Cheney's	42 12	90 21	1839.76	− 9.08	+2.19	− 6.89	....do	do.
Farmer's Creek	42 13	90 23	1839.76	− 9.18	+2.19	− 6.99	Locke	do.
White Water	42 18	90 38	1839.77	− 9.17	+2.19	− 6.98	Surveyors	do.
North Branch Maksquita	42 23	90 52	1839.77	− 9.58	+2.19	− 7.39	....do	do.
Little Makoqueta	42 31	90 31	1839.80	− 8.50	+2.19	− 6.31	....do	do.
Sherald's Mound	42 35	90 33	1839.80	− 8.17	+2.19	− 5.98	....do	do.
Log House	42 38	90 43	1839.80	− 9.00	+2.19	− 6.81	....do	do.
Turkey River	42 42	90 48	1839.81	− 9.00	+2.19	− 6.81	....do	do.
Ferry opposite Prairie du Chien	43 03	90 53	1839.82	− 9.08	+2.19	− 6.89	....do	do.
Council Bluffs	41 15	95 52	1878.66	−10.66	+0.28	−10.38	Thorpe	Proc. Roy. Soc., 1880.
Near Atalissa	41 38	91 14	1882.65	− 7.34	+0.16	− 7.18	Nipher	MS.
Aikins, Cedar County	41 43	91 14	1882.66	− 7.81	+0.16	− 7.65	....do	MS.
KANSAS, PART 1.								
Lawrence	38 58	95 15	1877.87	− 9.86	+0.33	− 9.53		
Humboldt	37 49	95 26	1878.55	−10.08	+0.30	− 9.78		
Emporia	38 26	96 12	1878.56	−10.84	+0.30	−10.54		
Great Bend (Fort Zarah)	38 24	98 43	1878.58	−11.08	+0.28	−10.80		
Dodge City	37 44	99 59	1878.59	−12.27	+0.27	−12.00		
Sargent	38 05	101 58	1878.61	−12.74	+0.25	−12.49		
KANSAS, PART 2.								
Fort Larned	38 10	98 57	1867.5	−12.00	+0.55	−11.45	Brown	MS.
New Fort Hayes	38 59	99 20	1867.5	−12.80	+0.55	−12.25	....do	MS.
Wallace	38 55	101 35	1872.78	−13.30	+0.38	−12.92	Hilgard	Nat. Acad. Sc.
Manhattan	39 12	96 35	1872.76	−10.86	+0.40	−10.46	....do	do.
Salina	39 30	97 39	1872.77	−12.80	+0.40	−12.40	....do	do.
Ellis	38 56	99 40	1872.77	−12.42	+0.38	−12.04	....do	do.
Fort Leavenworth	39 21	94 54	1858.5	−10.98*	+1.20	− 9.78	Simpson	Stone's Mag. Var., 1878.
Vermillion Creek	39 57	96 16	1858.6	−11.58*	+1.10	−10.48	....do	do.
Big Blue River	40 00	96 35	1858.6	−14.17*	+1.10	−13.07	....do	do.
Parsons	37 20	95 17	1879.65	− 9.55	+0.25	− 9.30	Nipher	Trans. St. Louis Acad. Sc.
KENTUCKY, PART 1.								
Paducah	37 05	88 37	1865.10	− 6.75	+1.06	− 5.69		
Twenty-seven-mile Island	36 57	88 14	1865.15	− 7.37	+1.06	− 6.31		
Patterson's Landing	37 03	88 25	1865.18	− 6.73	+1.06	− 5.67		
Oakland	37 02	86 15	1871.85	− 6.24	+0.75	− 5.49		
Shelbyville	38 13	85 13	1871.90	− 3.04	+0.85	− 2.19		
Falmouth	38 41	84 17	1872.01	− 3.36	+0.84	− 2.52		
Upper Point of Rocks	37 04	88 17	1865.13	− 7.42	+1.06	− 6.36		
Hickman	36 34	89 12	1881.73	− 5.79	+0.18	− 5.61		
Mayfield	36 45	88 41	1881.74	− 5.22	+0.18	− 5.04		
Madisonville	37 19	87 33	1881.76	− 5.10	+0.18	− 4.92		
Leitchfield	37 30	86 22	1881.77	− 3.32	+0.18	− 3.14		
Lebanon	37 36	85 19	1881.78	− 3.73	+0.19	− 3.54		
Stanford	37 31	84 44	1881.79	− 4.26	+0.19	− 4.07		
Livingston	37 23	84 20	1881.80	− 1.61	+0.19	− 1.42		
Cynthiana	38 26	84 25	1881.81	− 2.47	+0.20	− 2.27		
Flemingsburg	38 26	83 46	1881.83	− 1.76	+0.20	− 1.56		
Grayson	38 18	82 59	1881.84	− 1.46	+0.20	− 1.26		
KENTUCKY, PART 2.								
Augusta	38 50	83 50	1805.5	− 5.00	+2.95	− 2.05	Public survey	Sill. Jour., 1838.

* An index correction of + 1° was applied to Simpson's observations.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
KENTUCKY, PART 2—Continued.	° ′	° ′		°	°	°		
Williamsburg	36 47	84 10	1873.62	−2.07	+0.74	−1.33	Hilgard	Nat. Acad. Sc.
Guthrie	36 38	87 20	1875.47	−6.73	+0.55	−6.18	...do	do.
Crofton	37 02	87 40	1875.48	−6.26	+0.55	−5.71	...do	do.
Portland	38 16	85 55	1875.50	−3.63	+0.62	−3.01	...do	do.
Cave City	37 10	85 55	1875.50	−5.91	+0.57	−5.34	...do	do.
Nicholasville	37 56	84 38	1875.51	−2.80	+0.62	−2.18	...do	do.
Maysville	38 41	83 41	1875.52	−0.01	+0.62	+0.61	...do	do.
LOUISIANA, PART 1.								
Fort Livingston	29 16	89 57	1853.02	−7.64	+1.61	−6.03		
Isle Dernier	29 02	90 54	1853.14	−8.32	+1.61	−6.71		
New Orleans, Basin and Canal sts.	29 57	90 04	1858.26	−7.86	....	−6.18		
New Orleans, fair grounds	29 59	90 05	1880.23	−6.46	....	−6.18		
Cubitt	29 10	89 15	1859.95	−7.53	+1.34	−6.19		
Cote Blanche	29 44	91 43	1860.17	−8.36	+1.33	−7.03		
Pass à Loutre	29 11	89 01	1859.99	−7.50	+1.34	−6.16		
Magnolia Base	29 32	89 47	1872.05	−6.78	+0.76	−6.02		
Southwest Pass	28 59	89 23	1872.17	−6.09	+0.75	−5.34		
LOUISIANA, PART 2.								
Cheneyville	31 00	92 15	1807.5	−9.33	+1.61	−7.72	Public survey	Sill. Jour., 1838.
Public survey station	32 50	92 22	1835.5	−8.67	+1.98	−6.69	...do	Sill. Jour., 1840.
do	32 25	92 32	1836.5	−8.50	+1.96	−6.54	...do	do.
do	31 50	92 32	1834.5	−8.50	+1.98	−6.52	...do	do.
do	31 45	92 22	1834.5	−8.50	+1.98	−6.52	...do	do.
do	31 40	92 32	1835.5	−8.67	+1.98	−6.69	...do	do.
do	29 41	94 00	1840.5	−8.68	+1.55	−7.13	Bound. Com's.	do.
Osgood Island	29 11	89 05	1872.18	−6.18	+0.75	−5.43	Hilgard	Nat. Acad. Sc.
Avery's Island	29 55	91 45	1872.20	−7.33	+0.75	−6.58	...do	do.
Brashear City	29 41	91 14	1872.22	−6.88	+0.75	−6.13	...do	do.
Baton Rouge	30 26	91 12	1872.25	−6.99	+0.75	−6.24	...do	do.
Grand Ecore	31 48	93 07	1872.27	−7.87	+0.64	−7.23	...do	do.
Shreveport	32 30	93 45	1872.29	−8.00	+0.64	−7.36	...do	do.
Alexandria	31 17	92 27	1872.30	−7.73	+0.75	−6.98	...do	do.
Monroe	32 29	92 08	1872.32	−7.59	+0.75	−6.84	...do	do.
Gaines' Ferry	31 28	93 45	1840.4	−8.68	+1.55	−7.13	Graham	Trans. Am. Ph. Soc., 1846.
MAINE, PART 1.								
Agamenticus	43 13	70 42	1847.74	+10.16	+1.57	+11.73		
Mount Independence	43 46	70 19	1849.77	+11.77	+1.45	+13.22		
Kittery Point	43 05	70 43	1879.62	+12.52	....	+12.90		
Fletcher's Neck	43 27	70 20	1850.69	+11.29	+1.30	+12.59		
Richmond Island	43 33	70 14	1850.71	+12.30	+1.30	+13.60		
Portland, west	43 39	70 17	1866.12	+12.72	....	+13.25		
Mount Pleasant	44 02	70 49	1851.64	+14.53	+1.34	+15.87		
Kennebunkport	43 21	70 28	1851.65	+11.39	+1.65	+13.04		
Cape Neddick	43 12	70 36	1851.66	+11.15	+1.82	+12.97		
Cape Small	43 47	69 51	1851.80	+12.09	+1.33	+13.42		
Mount Sebattis	44 09	70 05	1853.57	+12.89	+1.24	+14.13		
Mount Ragged	44 13	69 09	1854.74	+14.28	+1.35	+15.63		
Camden Village	44 12	69 05	1854.83	+13.95	+1.34	+15.29		
Mount Harris	44 40	69 09	1855.67	+14.58	+1.29	+15.87		
Mount Saunders	44 39	68 36	1856.52	+14.99	+1.32	+16.31		
Southwest Harbor	44 15	68 18	1856.74	+15.42	+1.30	+16.72		
Mount Desert	44 21	68 14	1856.77	+15.24	+1.30	+16.54		
Calais	45 11	67 17	1857.71	+15.35	+1.48	+16.83		
Bangor	44 48	68 47	1879.64	+16.49	+0.18	+16.67		
Humpback	44 52	68 07	1858.65	+15.80	+1.42	+17.22		
Howard	44 38	67 24	1859.61	+18.53	+1.34	+19.87		
Cooper	44 59	67 28	1859.69	+16.53	+1.34	+17.87		
Eastport	44 54	66 59	1879.65	+19.13	....	+19.17		
Portland, east	43 40	70 15	1873.69	+12.73	....	+13.08		
Rockland	44 06	69 06	1863.52	+15.04	+0.85	+15.89		

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
MAINE, PART 1—Continued.	° ′	° ′		°	°	°		
Belfast	44 26	69 01	1863.52	+15.50	+0.85	+16.35		
Bath	43 55	69 49	1863.52	+12.86	+0.72	+13.58		
Freeport	43 51	70 06	1863.53	+14.20	+0.72	+14.92		
Harpswell	43 44	70 01	1863.55	+14.42	+0.72	+15.14		
Brunswick	43 54	69 58	1873.70	+14.30	+0.32	+14.62		
Epping Base, east end	44 40	67 50	1857.5	+16.33	+1.49	+17.82		
MAINE, PART 2.								
Hiram	43 50	70 45	1845.18	+11.97	+1.71	+13.68	Wadsworth	MS.
Timiscuata Lake	47 38	69 00	1818.5	+16.52	+4.57	+21.09	Johnson	Sill. Jour., 1838.
Matwaska	47 12	68 10	1818.5	+16.75	+4.57	+21.32	....do	do.
Source of Saint Croix	45 55	67 55	1817.5	+14.00	+4.35	+18.35	....do	do.
Forks of Penobscot	45 30	68 30	1840.5	+15.42	+3.02	+18.44	Barker	Pamp. by Getchell.
Mouth of Saint Croix	45 05	67 12	1797.5	+12.32	+5.64	+17.96	Chart	Sill. Jour., 1838.
Hampden	44 40	68 55	1840.5	+13.37	+2.35	+15.72	Barker	Pamp. by Getchell.
Greenville	45 24	69 35	1838.5	+11.00	+2.98	+13.98	State Com's	Sill. Jour., 1840.
Farmington	44 40	70 09	1840.5	+11.50	+2.42	+13.92	Geol. Rep	Pamp. by Getchell.
Umbagog Lake	44 42	70 53	1838.5	+13.00	+2.55	+15.55	State Com's	Sill. Jour., 1840.
Dixfield	44 32	70 14	1840.5	+12.17	+2.42	+14.59	Geol. Rep	Pamp. by Getchell.
Rumford	44 30	70 26	1840.5	+11.17	+2.42	+13.59	....do	do.
Waterville	44 28	69 32	1840.5	+12.60	+1.99	+14.59	....do	do.
Raymond	43 57	70 24	1838.5	+ 9.75	+2.12	+11.87	State Com's	Sill. Jour., 1840.
West Thomaston	43 56	69 05	1840.5	+12.18	+1.99	+14.17	Geol. Rep	Pamp. by Getchell.
Penobscot	45 30	68 45	1825.5	+14.75	+4.38	+19.13	Herrick	Becq. Traité du Mag., 1846.
Tachereau	45 49	70 24	1844.5	+14.12	+2.72	+16.84	Graham	Trans. Roy. Soc., 1872.
Big Black River	46 57	69 27	1844.5	+16.48	+2.86	+19.34	....do	do.
River Saint Francis	47 14	69 01	1843.5	+17.40	+2.73	+20.13	Bound. Sur	do.
do	47 11	68 56	1842.5	+17.05	+2.82	+19.87	....do	do.
Savage Island	47 16	68 44	1842.5	+17.97	+2.82	+20.79	....do	do.
Burgeois House	46 31	68 22	1842.0	+17.34	+2.87	+20.21	....do	do.
Lake Cleveland	47 12	68 14	1842.5	+17.88	+2.82	+20.70	....do	do.
Mouth of Green River	47 19	68 10	1843.5	+18.10	+2.73	+20.83	....do	do.
Fort Fairfield	46 46	67 50	1841.5	+17.45	+2.61	+20.06	....do	do.
Peconk Hill	46 59	67 47	1841.5	+17.72	+2.61	+20.33	Graham	do.
Aroostook Hill	46 47	67 47	1841.5	+17.47	+2.61	+20.08	....do	do.
Blue Hill	46 38	67 47	1841.5	+17.25	+2.61	+19.86	Bound. Sur	do.
Park's Hill	46 07	67 47	1841.5	+16.15	+2.61	+18.76	Graham	do.
Near Saint Croix River	45 57	67 47	1840.5	+16.00	+2.70	+18.70	....do	do.
Greenwood	44 20	70 45	1845.5	+12.13	+1.69	+13.82	Geol. Rep	Pamphlet by Getchell.
Bethel	44 27	70 51	1845.5	+11.83	+1.69	+13.52	....do	do.
North Vassalborough	44 30	69 40	1880.5	+15.58	+0.11	+15.69	Getchell	do.
Orono	44 54	68 40	1878.5	+16.67	+0.22	+16.89	State Coll	do.
Canada Boundary	46 25	70 03	1850.5	+15.75	+2.51	+18.26	Barker	do.
Near Mars Hill	46 30	67 54	1856.5	+18.00	+1.47	+19.47	....do	do.
Fort Kent	47 15	68 35	1843.5	+17.50	+2.73	+20.23	Me. and Mass. Sur.	do.
MARYLAND AND DISTRICT OF COLUMBIA, PART 1.								
Causten	38 56	77 04	1855.77	+ 1.07	+1	+ 2.74		
Washington, old C. S. office	38 53	77 01	1863.57	+ 2.70	....	+ 3.87		
Washington, Second and C streets, southeast.	38 53	77 00	1876.33	+ 3.31	....	+ 3.87		
Washington, First and B streets, southeast.	38 53	77 00	1882.45	+ 3.93	....	+ 3.87		
Taylor	39 00	76 28	1847.42	+ 2.30	+2.26	+ 4.56		
Kent Island, South Base	38 54	76 22	1845.42	+ 2.40	+2.37	+ 4.77		
Rosanne	39 18	76 43	1845.44	+ 2.18	+2.37	+ 4.55		
Finlay	39 24	76 32	1846.29	+ 2.31	+2.32	+ 4.63		
Osborne's Ruin	39 28	76 17	1845.47	+ 2.54	+2.37	+ 4.91		
Marriott	38 52	76 37	1849.46	+ 2.08	+2.14	+ 4.22		
North Point	39 12	76 27	1847.32	+ 1.66	+2.27	+ 3.93		
Bodkin Light	39 08	76 26	1847.31	+ 2.03	+2.27	+ 4.30		
Fort McHenry	39 16	76 35	1877.78	+ 4.18	....	+ 4.47		

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
MARYLAND AND DISTRICT OF COLUMBIA, PART 1—Cont'd.								
	° ′	° ′		°	°	°		
Pool's Island	39 17	76 16	1847.48	+ 2.49	+2.26	+ 4.75		
Susquehanna Light	39 32	76 05	1847.51	+ 2.23	+2.26	+ 4.49		
Kent Island	39 02	76 19	1849.49	+ 2.50	+2.14	+ 4.64		
Soper	39 05	76 57	1850.57	+ 2.12	+2.08	+ 4.20		
Hill	38 54	76 53	1868.83	+ 2.85	+0.95	+ 3.80		
Webb	39 05	76 40	1868.73	+ 2.93	+0.95	+ 3.88		
Davis	38 20	75 06	1853.73	+ 2.55	+1.89	+ 4.44		
Oxford	38 41	76 10	1856.64	+ 2.69	+1.71	+ 4.40		
Mason's Landing	38 14	75 15	1856.66	+ 2.38	+1.71	+ 4.09		
Cumberland	39 39	78 45	1864.22	+ 1.53	+1.24	+ 2.77		
Stabler	39 07	76 59	1869.65	+ 2.66	+0.90	+ 3.56		
Maryland Heights	39 20	77 43	1870.82	+ 2.93	+0.83	+ 3.76		
Calvert	38 22	76 24	1871.58	+ 2.81	+0.78	+ 3.59		
MARYLAND AND DISTRICT OF COLUMBIA, PART 2.								
Lonaconing	39 34	78 58	1879.55	− 3.00	+0.31	+ 3.31	Bracket	MS.
Annapolis	38 59	76 29	1879.4	+ 4.43	+0.32	+ 4.75	Very	MS.
MASSACHUSETTS, PART 1.								
Copeent	41 43	71 04	1844.77	+ 9.15	+2.27	+11.42		
Indian	41 26	70 41	1846.61	+ 8.82	+2.17	+10.99		
Shootflying	41 41	70 21	1846.66	+ 9.67	+2.17	+11.84		
Manomet	41 56	70 36	1867.58	+10.41	+0.82	+11.23		
Blue Hill	42 13	71 07	1845.75	+ 9.22	+2.18	+11.40		
Fairhaven	41 37	70 54	1845.80	+ 8.90	+2.20	+11.10		
Sampson's Hill	41 23	70 29	1846.56	+ 8.81	+2.18	+10.99		
Nantucket Beach	41 18	70 06	1855.64	+ 9.97	....	+11.50		
Tarpaulin Cove	41 28	70 45	1846.60	+ 9.20	+2.15	+11.35		
Hyannis	41 38	70 18	1846.65	+ 9.36	+2.15	+11.51		
South Boston Heights	42 20	71 02	1872.75	+11.25	....	+11.78		
Nantasket	42 18	70 54	1847.67	+ 9.62	+2.04	+11.66		
Little Nahant	42 26	70 56	1849.63	+ 9.68	+1.90	+11.58		
Fort Lee, Salem	42 32	70 52	1855.65	+10.83	+1.77	+12.60		
Beaconhill, Gloucester	42 36	70 39	1859.52	+12.05	+1.93	+13.98		
Annisquam	42 39	70 41	1849.66	+11.61	+2.70	+14.31		
Baker's Island Light	42 32	70 47	1849.67	+12.28	+2.93	+15.21		
Coddon's Hill	42 31	70 51	1849.68	+11.83	+2.93	+14.76		
Plum Island, near Newburyport	42 48	70 49	1859.53	+10.97	+1.70	+12.67		
Thompson	42 37	70 44	1859.52	+11.15	+1.82	+12.97		
Rockport	42 40	70 37	1859.53	+11.62	+1.82	+13.44		
Ipswich	42 41	70 50	1859.53	+11.23	+1.82	+13.05		
Chatham Lights	41 40	69 57	1860.69	+11.19	+1.22	+12.41		
Wellfleet	41 56	70 02	1860.70	+10.72	+1.22	+11.94		
Provincetown	42 03	70 11	1860.71	+11.39	+1.22	+12.61		
Wachusett	42 29	71 53	1860.72	+ 8.80	+1.34	+10.14		
Easthampton	42 15	72 40	1862.52	+ 9.07	+1.25	+10.32		
Nantucket, cliff	41 17	70 06	1879.58	+11.46	....	+11.50		
Vineyard Haven	41 28	70 36	1875.72	+10.57	+0.43	+11.00		
Deerfield	42 33	72 36	1859.56	+ 9.42	+1.50	+10.92		
Chesterfield	42 24	72 51	1859.56	+ 8.90	+1.58	+10.48		
Springfield	42 06	72 32	1859.57	+ 8.65	+1.50	+10.15		
Cambridge, observatory	42 23	71 08	1879.60	+11.77	....	+11.78		
MASSACHUSETTS, PART 2.								
Beverly	42 33	70 52	1781.5	+ 7.03	+6.31	+13.34	....	Mem. Am. Acad., 1846.
Williamstown	42 43	73 13	1837.5	+ 7.75	+3.36	+11.11	Hopkins	Sill. Jour., 1840.
Plymouth	41 58	70 39	1876.53	+10.91	+0.33	+11.24	Hilgard	Nat. Acad. Sc.
House Point Island, Cape Cod	42 03	70 04	1835.5	+ 9.33	+2.88	+12.21	Govt. Survey	Sill. Jour., 1840.
Southwick	42 04	72 46	1838.5	+ 8.25	+3.03	+11.28	Holcomb	do.
Near Springfield	42 12	72 36	1875.5	+ 9.47	+0.56	+10.03	Ellis	Ch. of Eng's Rep., 1878.
Salem	42 31	70 54	1877.5	+11.50	+1.10	+12.60	Harris	MS.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD.	$D_{1885.0}$	Observer.	Reference.
MASSACHUSETTS, PT. 2.—Cont'd.	° ′	° ′		°	°	°		
Lynn	42 28	70 56	1877.5	+11.25	+0.41	+11.66	Harris	MS.
Lowell	42 39	71 20	1876.55	+10.80	+0.50	+11.30	Hilgard	Nat. Acad. Sc.
Fitchburg	42 35	71 48	1876.56	+10.73	+0.37	+11.10	do	do.
Greenfield	42 35	72 35	1876.56	+10.34	+0.39	+10.73	do	do.
North Adams	42 42	73 07	1876.57	+10.51	+0.45	+10.96	do	do.
MICHIGAN, PART 1.								
Sault de Ste. Marie	46 30	84 20	1880.60	+ 1.08		+ 1.18		
Grand Haven	43 05	86 13	1880.55	— 2.43		— 2.15		
Mackinac	45 51	84 40	1880.57	+ 0.34	+0.25	+ 0.59		
Ontonagon	46 52	89 31	1880.63	— 4.69	+0.33	— 4.36		
Kalamazoo	42 17	85 35	1880.97	— 2.77	+0.38	— 2.39		
MICHIGAN, PART 2.								
Tawas City	44 16	83 30	1856.5	— 2.08	+1.62	— 0.46	Chart	U. S. Lake Sur.
Near Duncan City	45 37	84 07	1851.5	— 1.88	+1.88	0.00	do	do.
25 miles east of Fort Mackinac	45 50	84 00	1851.5	— 1.88	+1.88	0.00	do	do.
4 miles west of Isle aux Galet's Light.	45 40	85 10	1853.5	— 2.75	+1.81	— 0.94	do	do.
Point Epoufette	46 04	85 07	1854.7	— 2.50	+1.76	— 0.74	do	do.
Seul Choix Point	45 55	85 50	1855.7	— 3.93	+1.72	— 2.21	do	do.
Garden Island	45 48	85 25	1854.5	— 2.71	+1.77	— 0.94	do	do.
Whiskey Island	45 48	85 32	1854.6	— 3.81	+1.77	— 2.04	do	do.
Hat Island	45 49	85 13	1853.7	— 3.20	+1.81	— 1.39	do	do.
Middle Village	45 33	85 02	1853.6	— 2.62	+1.81	— 0.81	do	do.
Wangoshane Point	45 46	84 56	1853.5	— 2.21	+1.81	— 0.40	do	do.
Beaver Island, South Point	45 34	85 29	1855.5	— 4.05	+1.72	— 2.33	do	do.
East Neebish Rapids	46 20	84 10	1853.5	— 0.25	+1.81	+ 1.56	do	do.
Eagle Harbor	47 28	88 03	1855.7	— 2.66	+1.72	— 0.94	do	do.
Forestville	43 40	82 34	1873.53	+ 1.51	+0.64	+ 2.15	Smith	Sur. of N. and N. W. Lakes, 1859.
Sand Point	43 55	83 23	1858.71	— 0.53	+1.50	+ 0.97	do	do.
Thunder Bay	45 02	83 09	1858.64	+ 1.23	+1.55	+ 2.78	do	do.
Sturgeon Point	44 43	83 14	1858.74	— 1.03	+1.52	+ 0.49	do	do.
Fort Gratiot	43 00	82 25	1873.53	+ 0.62	+0.58	+ 1.20	Lee	Sur. of N. and N. W. Lakes, 1873.
Detroit	42 20	83 03	1876.42	— 0.08		+ 0.35	Bailey	Ch. of Eng's Rep., 1877.
Marquette	46 33	87 24	1873.57	— 4.51	+0.76	— 3.75	Lee	Sur. of Lakes, 1873.
Copper Harbor	47 28	87 51	1873.58	— 4.06	+0.76	— 3.30	do	do.
Stony Point	41 56	83 15	1848.5	— 2.12	+2.01	— 0.11	U. S. Top. Engs	C. S. Rep., 1856.
Point aux Barques	44 01	82 47	1857.5	+ 0.01	+1.56	+ 1.57		MS. by Raynolds.
Saginaw River	43 39	83 51	1856.5	— 1.47	+1.63	+ 0.16		do.
Grand Island	46 34	86 41	1867.6	— 3.25	+1.12	— 2.13	Chart	U. S. Lake Sur., 1872.
Portage Entry	46 59	88 27	1863.5	— 4.62	+1.34	— 3.28		MS. by Raynolds.
Fort Wilkins, Copper Harbor	47 28	87 49	1864.5	— 4.73	+1.28	— 3.45		do.
South Manitou Island	45 02	86 06	1860.5	— 3.15	+1.88	— 1.27		do.
Monistique River	45 57	86 10	1864.5	— 3.10	+1.28	— 1.82		do.
Near Escanaba	45 41	87 05	1863.5	— 1.90	+1.34	— 0.56		do.
Saint Joseph	42 07	86 28	1856.5	— 4.15	+2.01	— 2.14	Graham	do.
Northport, Grand Traverse Bay	45 06	85 35	1860.5	— 2.55	+1.88	— 0.67		do.
Traverse City	44 46	85 37	1860.5	— 2.38	+1.88	— 0.50		do.
Michigan shore	44 31	85 32	1838.5	— 4.50	+2.66	— 1.84	Geol. Rep	Sill. Jour., 1840.
Geological Station	44 31	84 56	1838.5	— 2.83	+2.66	— 0.17	do	do.
do	44 31	84 28	1838.5	— 2.75	+2.62	— 0.13	do	do.
do	44 31	83 50	1838.5	— 2.00	+2.39	+ 0.39	do	do.
20 miles west of Point of Barques	43 51	83 06	1835.5	— 2.10	+2.56	+ 0.46	do	do.
Public Survey Station	43 45	84 22	1832.5	— 2.92	+2.66	— 0.26	Pub. Sur	do.
Père Marquette River	43 44	85 43	1837.5	— 4.57	+3.08	— 1.49	Geol. Rep	do.
Little Point aux Sables	43 31	85 54	1837.5	— 6.00	+3.08	— 2.92	do	do.
Wahley	43 22	82 32	1860.36	+ 1.08	+1.50	+ 2.58	Smith	U. S. Lake Sur. Rep., 1880.
Beaver Island	45 45	85 30	1860.75	— 2.72	+1.60	— 1.12	do	do.
Public Survey Station	43 20	84 22	1832.5	— 3.00	+2.95	— 0.05	Pub. Sur	Sill. Jour., 1840.
do	43 19	85 59	1837.5	— 6.25	+3.08	— 3.17	Geol. Rep	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
MICHIGAN, PART 2—Continued.	° ′	° ′		°	°	°		
Public Survey Station	43 00	84 22	1831.5	− 3.45	+2.97	− 0.48	Pub. Sur	Sill. Jour., 1840.
do	42 30	84 22	1826.5	− 4.42	+3.04	− 1.38	...do	do.
Marshall	42 16	84 58	1876.79	− 1.70	+0.66	− 1.04	Powell	Ch. of Eng's Rep., 1877.
Saginaw	43 25	83 58	1876.72	− 0.39	+0.66	+ 0.27	Lockwood	do.
Saint Louis	43 24	84 36	1876.79	− 0.98	+0.75	− 0.23	...do	do.
Point on shore	46 48	90 01	1824.5	−10.25			Bayfield	Phil. Trans. Roy. Soc., 1872.
Huron River	46 55	88 07	1824.5	− 7.93			...do	do.
Small River	46 32	87 10	1824.5	− 7.35			...do	do.
White Fish Point	46 46	84 57	1867.6	− 0.92	+1.12	+ 0.20	Chart	U. S. Lake Sur., 1872.
False Presque Isle	45 18	83 37	1817.5	− 2.98	+2.23	− 0.75	Bayfield	Phil. Trans. Roy. Soc., 1872.
General Land Survey Station	42 35	85 48	1826.5	− 5.36	+3.01	− 2.35	Gen. Land Sur	MS.
do	42 35	85 56	1830.2	− 5.20	+3.08	− 2.12	...do	MS.
do	42 35	86 03	1831.8	− 5.58	+3.09	− 2.49	...do	MS.
Grand Marais	46 41	85 57	1867.7	− 2.03	+1.11	− 0.92	Chart	U. S. Lake Sur., 1872.
MINNESOTA, PART 1.								
Minneapolis	44 59	93 14	1877.75	−10.22	+0.63	− 9.59		
Brainerd	46 21	94 15	1880.66	− 9.59	+0.38	− 9.21		
Glyndon	46 52	96 40	1880.68	−11.44	+0.28	−11.16		
Fort Snelling Reservation	44 54	93 11	1880.74	−10.23	+0.38	− 9.85		
Heron Lake	43 48	95 24	1880.76	−10.23	+0.23	−10.00		
MINNESOTA, PART 2.								
Lake of the Woods, Buffalo Point	49 00	95 15	1874.05	−11.50	+0.55	−10.95	Twining	N. W. Bound. Sur., 1872-'74
Northwest Boundary Station	49 00	96 30	1873.96	−13.17	+0.55	−12.62	...do	do.
do	49 00	96 25	1873.96	−12.42	+0.55	−11.87	...do	do.
do	49 00	96 10	1873.98	−12.00	+0.55	−11.45	...do	do.
do	49 00	95 00	1874.06	−11.20	+0.55	−10.65	...do	do.
do	49 00	94 55	1874.07	−11.08	+0.55	−10.53	...do	do.
do	49 00	94 45	1874.08	−10.92	+0.55	− 10.37	...do	do.
Princeton	45 42	93 20	1858.61	−10.22			Garrison	MS.
Minnesota Point	46 46	92 05	1859.55	− 9.42			Smith	Sur. of N. and N. W. Lakes 1859.
Lake of the Woods	49 00	94 00	1823.5	−11.02			Long	Sill. Jour., 1838.
Duluth	46 46	92 04	1873.61	−11.87	+0.99	−10.88	Lee	U. S. Lake Sur., 1873.
Saint Paul	44 57	93 05	1873.63	−10.93	+0.99	− 9.94	...do	do.
Island in Rainy Lake	48 35	92 30	1823.5	− 8.25			Long	Sill. Jour., 1838.
North shore, Lake Superior	47 58	90 00	1823.5	− 6.35			...do	do.
Henderson	44 32	93 56	1855.5	−11.50			Allanson	MS.
Wabasha	44 18	92 07	1876.61	− 8.07	+0.55	− 7.52	Bailey	Ch. of Eng's Rep., 1877.
Point on shore	46 42	91 50	1824.5	−12.33			Bayfield	Phil. Trans. Roy. Soc., 1872.
do	46 48	91 30	1824.5	−12.45			...do	do.
do	47 33	90 50	1824.5	−10.50			...do	do.
Red Wing	44 34	92 32	1878.77	− 7.83	+0.42	− 7.41	Powell	U. S. Lake Sur. Rep., 1879.
Near Fond du Lac	46 43	92 10	1824.5	−12.50			Bayfield	Phil. Trans. Roy. Soc., 1872.
MISSISSIPPI, PART 1.								
Mississippi City	30 23	89 02	1855.24	− 7.36	+1.43	− 5.93		
MISSISSIPPI, PART 2.								
Ship Island	30 13	88 58	1841.5	− 7.58	+1.71	− 5.87		From a chart.
Natchez	31 34	91 24	1872.30	− 7.25	+0.74	− 6.51	Hilgard	Nat. Acad. Sc.
Scooba	32 50	88 30	1833.5	− 6.92	+1.70	− 5.22		MS.
Corinth	34 56	88 35	1875.40	− 6.36	+0.53	− 5.83	Hilgard	Nat. Acad. Sc.
Grenada	33 47	80 50	1872.18	6.42	+0.68	− 5.74	...do	do.
Vicksburg	32 21	90 53	1875.42	− 7.32	+0.57	− 6.75	Poole	do.
Jackson	32 19	90 12	1872.32	− 7.34	+0.74	− 6.60	...do	do.
Pascagoula	30 21	88 33	1875.41	− 6.32	+0.55	− 5.77	...do	do.
West Point	33 33	88 38	1875.43	− 6.42	+0.53	− 5.89	...do	do.
Meridian	32 20	88 44	1875.43	− 6.43	+0.53	− 5.90	...do	do.
Cat Island	30 15	89 06	1847.5	− 7.20	+1.63	− 5.57	Barnett	Phil. Trans. Roy. Soc., 1874.
Macon	33 08	88 38	1833.5	− 7.50	+1.70	− 5.80	Campbell	MS.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
MISSOURI, PART 1.	° ′	° ′		°	°	°		
Cape Girardeau	37 18	89 33	1865.21	− 6.58	+1.10	− 5.48		
Wittemberg	37 39	89 33*	1865.26	− 6.78	+1.10	− 5.68		
MISSOURI, PART 2.								
Franklin	38 57	92 57	1819.54	−11.70	+3.21	− 8.49	Long's Exp'n	Sill. Jour., 1838.
Cow Island	39 25	94 00	1819.63	−11.54	+3.21	− 8.33	...do	do.
Public Survey Station	37 30	90 02	1827.5	− 7.50	+2.98	− 4.52	Pub. Sur	Sill. Jour., 1840.
do	37 00	90 02	1823.5	− 8.00	+2.76	− 5.24	...do	do.
do	37 00	90 12	1823.5	− 8.00	+2.76	− 5.24	...do	do.
do	36 50	90 02	1823.5	− 7.50	+2.76	− 4.74	...do	do.
Hermann	38 42	91 27	1872.74	− 8.23	+0.68	− 7.55	Hilgard	Nat. Acad. Sc.
Sedalia	38 42	93 16	1879.60	− 8.76	+0.30	− 8.46	Nipher	Trans. St. Louis Acad. Sc. and MS.
Kansas City	39 07	94 38	1879.57	−10.13	+0.27	− 9.86	...do	Trans. St. Louis Acad. Sc.
Lebanon, old and new station	37 40	92 40	1880.62	− 7.77	+0.25	− 7.52	...do	do.
Poplar Bluff	36 45	90 22	1880.52	− 6.75	+0.25	− 6.50	...do	do.
Wright City	38 47	91 00	1878.53	− 8.23	+0.36	− 7.87	...do	do.
Mexico	39 11	91 52	1878.53	− 7.64	+0.36	− 7.28	...do	do.
Columbia, old and new station	38 56	92 19	1880.10	− 7.55	+0.27	− 7.28	...do	Trans. St. Louis Acad. Sc. and MS.
Louisiana	39 28	91 07	1878.55	− 7.12	+0.36	− 6.76	...do	Trans. St. Louis Acad. Sc.
Hannibal	39 44	91 24	1878.56	− 7.14	+0.36	− 6.78	...do	do.
Canton	40 09	91 36	1878.57	− 7.32	+0.36	− 6.96	...do	do.
Memphis	40 27	92 13	1878.58	− 7.80	+0.32	− 7.48	...do	do.
Kirksville	40 12	92 37	1882.61	− 8.28	+0.12	− 8.16	...do	do.
Public Survey Station	36 40	90 02	1825.5	− 8.00	+3.06	− 4.94	Pub. Survey	Sill. Jour., 1840.
Glasgow	39 13	92 50	1879.55	− 8.36	+0.28	− 8.08	Nipher	Trans. St. Louis Acad. Sc.
Chillicothe	39 47	93 34	1879.56	− 8.52	+0.27	− 8.25	...do	do.
Carrollton	39 21	93 33	1879.57	− 8.50	+0.27	− 8.23	...do	do.
Saint Joseph	39 46	94 49	1879.58	− 8.89	+0.25	− 8.64	...do	do.
Maryville	40 21	94 58	1879.59	−11.23	+0.24	−10.99	...do	do.
Jefferson City	38 35	92 09	1881.65	− 8.42	+0.19	− 8.23	...do	do.
Washington, old and new station	38 31	90 59	1181.53	− 6.32	+0.19	− 6.13	...do	do.
Holden	38 38	94 03	1879.63	− 8.93	+0.26	− 8.67	...do	do.
Lexington	39 12	93 53	1879.64	− 8.92	+0.26	− 8.66	...do	do.
Schell City	38 03	94 05	1879.65	− 9.04	+0.26	− 8.78	...do	do.
Springfield	37 16	93 15	1879.66	− 8.60	+0.30	− 8.30	...do	do.
Lutesville	37 20	89 59	1880.52	− 6.23	+0.25	− 5.98	...do	do.
Charleston	36 56	89 19	1880.52	− 5.72	+0.25	− 5.47	...do	do.
Doniphan	36 38	90 47	1880.53	− 7.08	+0.25	− 6.83	...do	do.
Gatewood	36 32	91 03	1880.53	− 7.20	+0.25	− 6.95	...do	do.
Piedmont	37 08	90 41	1880.54	− 7.38	+0.25	− 7.13	...do	do.
Arcadia	37 46	90 41	1880.54	− 6.81	+0.25	− 6.56	...do	do.
Pilot Knob, base	37 37	90 37	1880.55	−11.14*			...do	do.
Pilot Knob, top	37 37	90 37	1880.55	− 3.76*			...do	do.
De Soto	38 07	90 35	1880.55	− 7.78	+0.25	− 7.53	...do	do.
Kimmswick	38 20	90 26	1880.56	− 6.76	+0.25	− 6.51	...do	do.
Cuba	38 04	91 21	1880.57	− 7.41	+0.25	− 7.16	...do	do.
Salem	37 39	91 31	1880.58	− 6.94	+0.25	− 6.69	...do	do.
Houston	37 19	91 55	1880.58	− 7.58	+0.25	− 7.33	...do	do.
Howell County	36 56	91 55	1880.59	− 7.52	+0.25	− 7.27	...do	do.
O'Fallon	38 47	90 43	1880.83	− 6.76	+0.23	− 6.53	...do	do.
Rolla	37 58	91 45	1880.5	− 6.88	+0.25	− 6.63	Emerson	do.
Near Clayton and Saint Charles Rockroad.	38 41	90 20	1882.08	− 6.10	+0.17	− 5.93	Nipher	Trans. St. Louis Acad. Sc. and MS.
Ten-Mile House and Kirkwood	38 37	90 24	1881.98	− 6.60	+0.17	− 6.43	...do	do.
Pacific, formerly Franklin	38 28	90 44	1881.52	− 6.90	+0.20	− 6.70	...do	Trans. St. Louis Acad. Sc.
Union	38 25	90 59	1881.52	− 6.60	+0.20	− 6.40	...do	do.
Roedersville	38 24	91 10	1881.52	− 6.93	+0.20	− 6.73	...do	do.
Wulfert's farm	38 24	91 16	1881.54	− 7.07	+0.20	− 6.87	...do	do.
Canaan and Dry Fork	38 18	91 34	1881.54	− 7.18	+0.20	− 6.98	...do	do.

*Local deflection.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
MISSOURI. PART 2—Continued.	° ′	° ′		°	°	°		
Vienna	38 12	91 54	1881.54	− 7.25	+0.20	− 7.05	Nipher	Trans. St. Louis Acad. Sc.
Lawson's farm	38 11	92 11	1881.55	− 6.90	+0.20	− 6.70	...do	do.
Tuscumbia	38 12	92 30	1881.55	− 8.51	+0.20	− 8.31	...do	do.
Versailles.	38 25	92 53	1881.56	− 8.33	+0.20	− 8.13	...do	do.
Soap Creek	38 17	92 50	1881.57	− 8.34	+0.20	− 8.14	...do	do.
Linn Creek	38 04	92 47	1881.57	− 9.00	+0.20	− 8.80	...do	do.
Decaturville	37 54	92 43	1881.58	− 8.94	+0.19	− 8.75	...do	do.
Buffalo, and farm of F. Voris	37 36	93 08	1881.58	− 8.13	+0.19	− 7.94	...do	do.
Bolivar	37 35	93 24	1881.59	− 8.24	+0.19	− 8.05	...do	do.
Wheatland	37 56	93 24	1881.60	− 8.66	+0.19	− 8.47	...do	do.
Warsaw	38 14	93 23	1881.60	− 8.85	+0.19	− 8.66	...do	do.
Lincoln	38 23	93 21	1881.60	− 9.31	+0.19	− 9.12	...do	do.
Windsor	38 32	93 33	1881.60	− 8.72	+0.18	− 8.54	...do	do.
G. Zimmerman's place	38 41	93 34	1881.61	− 9.25	+0.18	− 9.07	...do	do.
Swope's, or Black Water	38 52	93 35	1881.61	− 8.62	+0.18	− 8.44	...do	do.
Sweet Springs	38 55	93 29	1881.62	− 9.40	+0.18	− 9.22	...do	do.
Herndon	39 00	93 21	1881.62	− 8.92	+0.18	− 8.74	...do	do.
Marshall	39 08	93 17	1881.62	− 8.54	+0.18	− 8.36	...do	do.
Arrow Rock and Clark's farm	39 04	92 58	1881.63	− 7.90	+0.18	− 7.72	...do	do.
Johnson's farm and Prairie Home	38 50	92 40	1881.64	− 7.56	+0.18	− 7.38	...do	do.
California Station and Centretown.	38 38	92 34	1881.64	− 7.68	+0.18	− 7.50	...do	do.
Marion	38 42	92 25	1881.65	− 7.66	+0.18	− 7.48	...do	do.
Providence	38 49	92 28	1881.66	− 7.65	+0.18	− 7.47	...do	do.
McCredie	38 58	91 55	1881.67	− 7.84	+0.19	− 7.65	...do	do.
Loomis' farm	38 57	91 47	1881.67	− 7.77	+0.19	− 7.58	...do	do.
Danville	38 51	91 32	1881.67	− 7.80	+0.19	− 7.61	...do	do.
Warrenton	38 46	91 09	1882.63	− 6.56	+0.13	− 6.43	...do	MS.
Dardenne and Healds	38 43	90 41	1882.15	− 6.66	+0.16	− 6.50	...do	Trans. St. Louis Acad. Sc. and MS.
Opposite Saint Charles and Pattonsville.	38 43	90 30	1881.68	− 6.61	+0.19	− 6.42	...do	Trans. St. Louis Acad. Sc.
Florissant	38 47	90 17	1881.68	− 6.58	+0.19	− 6.39	...do	do.
Newport and Goebel's	38 35	91 06	1882.47	− 7.31	+0.15	− 7.16	...do	MS.
E. Ruck's	38 41	91 20	1882.48	− 7.85	+0.14	− 7.71	...do	MS.
Fred. Bruhn's	38 37	91 29	1882.48	− 6.87	+0.14	− 6.73	...do	MS.
F. Kaldeweiher's	38 28	91 41	1882.49	− 7.74	+0.14	− 7.60	...do	MS.
Linn, Osage County	38 28	91 50	1882.49	− 7.62	+0.14	− 7.48	...do	MS.
Little Auxvasse Creek	38 43	92 01	1882.50	− 7.92	+0.14	− 7.78	...do	MS.
Steven's store	38 58	92 05	1882.50	− 7.61	+0.14	− 7.47	...do	MS.
Centralia	39 13	92 05	1882.51	− 7.95	+0.14	− 7.81	...do	MS.
Long Branch of Salt River	39 24	92 10	1882.51	− 8.11	+0.14	− 7.97	...do	MS
Moberly	39 26	92 26	1882.51	− 7.66	+0.14	− 7.52	...do	MS.
Macon	39 46	92 30	1882.52	− 7.98	+0.14	− 7.84	...do	MS.
Isaac Lewis'	39 48	92 37	1882.52	− 7.98	+0.14	− 7.84	...do	MS.
Mercyville	39 57	92 42	1882.53	− 8.28	+0.14	− 8.14	...do	MS.
West Branch of Yellow Creek	39 54	93 07	1882.53	− 8.27	+0.14	− 8.13	...do	MS.
Linneus	39 51	93 13	1882.54	− 7.93	+0.14	− 7.79	...do	MS.
One mile west of Laclede	39 47	93 17	1852.54	− 8.18	+0.14	− 8.04	...do	MS.
Wolford's	39 38	93 45	1882.55	− 8.67	+0.14	− 8.53	...do	MS.
Kingston and Smith's	39 40	94 08	1882.55	− 9.42	+0.13	− 9.29	...do	MS.
Maysville	39 43	94 24	1882.56	− 9.30	+0.13	− 9.17	...do	MS.
Johnson's	40 01	94 23	1882.56	− 9.55	+0.13	− 9.42	...do	MS.
Albany	40 15	94 21	1882.57	− 8.43	+0.13	− 8.30	...do	MS.
Station in	40 16	94 17	1882.57	− 8.55	+0.13	− 8.42	...do	MS.
Bethany	40 16	94 03	1882.57	− 8.72	+0.13	− 8.59	...do	MS.
Honan's & Michael's	40 06	93 54	1882.58	− 8.79	+0.13	− 8.66	...do	MS.
Trenton	40 03	93 39	1882.58	− 8.06	+0.13	− 7.93	...do	MS.
Amick's	40 13	93 38	1882.59	− 8.23	+0.13	− 8.10	...do	MS.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
MISSOURI, PART 2—Continued.	° ′	° ′		°	°	°		
Princeton	40 24	93 39	1882.59	− 8.79	+0.13	− 8.66	Nipher	MS.
Williams'	40 27	93 21	1882.59	− 8.65	+0.13	− 8.52	...do	MS.
Ward's and Unionville	40 28	93 06	1882.60	− 8.25	+0.13	− 8.12	...do	MS.
Bankes'	40 19	93 07	1882.60	− 8.63	+0.13	− 8.50	.. do	MS.
Milan	40 12	93 11	1882.60	− 8.30	+0.13	− 8.17	...do	MS.
Shicklerville	40 09	92 58	1882.60	− 8.87	+0.13	− 8.74	...do	MS.
La Plata	40 00	92 34	1882.61	− 8.15	+0.13	− 8.02	.. do	MS.
Harris	39 53	92 22	1882.61	− 7.62	+0.13	− 7.49	...do	MS.
Shelbyville	39 44	92 04	1882.62	− 7.78	+0.13	− 7.65	...do	MS.
Winkler's	39 35	92 00	1882.62	− 7.74	+0.13	− 7.61	...do	MS.
Long Branch of Salt River	39 22	91 59	1882.62	− 8.00	+0.13	− 7.87	...do	MS.
Montgomery City	39 00	91 30	1882.63	− 7.12	+0.13	− 6.99	...do	MS.
Gray's Summit	38 29	90 49	1882.46	− 6.91	+0.13	− 6.78	.. do	MS.
MONTANA TERRITORY, PART 1.								
Fort Ellis	45 40	110 58	1882.66	−19.58	0.00	−19.58		
MONTANA TERRITORY, PART 2.								
Northwest Boundary Station, near Divide.	49 00	114 00	1874.6	−23.33	0.00	−23.33	Twining	N. Bound. Sur., 1878.
Northwest Boundary Station, near Milk River.	49 00	113 00	1874.6	−22.83	0.00	−22.83	...do	do.
Northwest Boundary Station, near Sweet Grass Hill.	49 00	111 30	1874.6	−22.42	+0.05	−22.37	...do	do.
Northwest Boundary Station, near Milk River.	49 00	110 30	1874.5	−22.00	+0.07	−21.93	...do	do.
Northwest Boundary Station	49 00	109 00	1874.5	−21.00	+0.10	−20.90	.. do	do.
do	49 00	107 30	1874.5	−20.75	+0.12	−20.63	...do	do.
do	49 00	106 30	1874.5	−20.33	+0.13	−20.20	...do	do.
do	49 00	105 30	1874.5	−19.83	+0.14	−19.69	...do	do.
Northwest Boundary Station, near Salt Lakes.	49 00	104 30	1874.5	−18.50	+0.15	−18.35	... do	do.
Northwest Boundary Station	49 00	104 05	1873.7	−18.42	+0.15	−18.27	...do	do.
do	49 00	104 20	1873.7	−18.83	+0.15	−18.68	...do	do.
do	49 00	104 45	1873.7	−18.25	+0.15	−18.10	...do	do.
do	49 00	105 10	1873.7	−19.53	+0.15	−19.38	...do	do.
do	49 00	105 25	1873.8	−19.93	+0.15	−19.78	...do	do.
do	49 00	105 33	1873.8	−19.75	+0.15	−19.60	...do	do.
do	49 00	105 45	1874.5	−20.25	+0.14	−20.11	...do	do.
do	49 00	105 55	1874.5	−19.83	+0.14	−19.69	...do	do.
do	49 00	106 05	1874.5	−20.33	+0.14	−20.19	...do	do.
do	49 00	106 28	1874.5	−20.50	+0.13	−20.37	... do	do.
do	49 00	106 45	1874.6	−20.17	+0.13	−20.04	...do	do.
do	49 00	106 50	1874.6	−20.33	+0.13	−20.20	...do	do.
do	49 00	106 55	1874.6	−20.00	+0.13	−19.87	.. do	do.
do	49 00	107 10	1874.6	−20.67	+0.12	−20.55	...do	do.
do	49 00	107 15	1874.6	−20.17	+0.12	−20.05	...do	do.
do	49 00	107 40	1874.6	−20.83	+0.12	−20.71	...do	do.
do	49 00	107 50	1874.6	−20.63	+0.12	−20.51	...do	do.
do	49 00	109 40	1874.6	−20.38	+0.10	−20.28	...do	do.
do	49 00	110 45	1874.6	−22.75	+0.07	−22.68	...do	do.
do	49 00	111 05	1874.6	−22.17	+0.06	−22.11	...do	do.
do	49 00	111 28	1874.6	−22.67	+0.05	−22.62	...do	do.
do	49 00	111 35	1874.6	−22.17	+0.05	−22.12	...do	do.
do	49 00	112 00	1874.6	−22.50	+0.03	−22.47	...do	do.
do	49 00	112 35	1874.6	−22.50	+0.02	−22.48	...do	do.
do	49 00	112 55	1874.6	−22.53	0.00	−22.53	...do	do.
do	49 00	113 05	1874.6	−23.27	0.00	−23.27	...do	do.
do	49 00	113 20	1874.6	−23.75	0.00	−23.75	...do	do.
Northwest Boundary Station, near R. M. Divide.	49 00	113 40	1874.6	−23.83	0.00	−23.83	...do	do.
South Crossing, Kootenay	48 22	115 21	1861.51	−22.27	−0.20	−22.47	Haig	Phil. Trans. Roy. Soc., 1864.
On Kootenay River	48 40	115 17	1861.51	−23.40	−0.20	−23.60	...do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
MONTANA, PART 2—Continued.	° ′	° ′		°	°	°		
Fort Union	48 03	104 00	1853.5	−16.80	+0.10	−16.70	Stevens	C. S. Rep., 1856.
Fort Benton	47 50	110 39	1860.5	−20.40	+0.10	−20.30	Mullan	Stone's Mag. Var., 1878.
Fort Owen	46 31	113 58	1853.5	−19.42	−0.25	−19.67	Stevens	C. S. Rep., 1856.
Camp Kishenehu	49 00	114 21	1861.5	−22.97	−0.15	−23.12	Harris	MS. Chart Bound. Sur.
Camp Kootenay, east	48 59	115 12	1861.5	−22.97	−0.20	−23.17	....do	do.
Powder River	45 47	105 03	1859.5	−16.90	+0.10	−16.80		MS. by Raynolds.
Rosebud River	46 03	106 23	1859.5	−17.83	+0.10	−17.73		do.
Fort Sarpy	46 18	107 04	1859.5	−18.00	+0.10	−17.90		do.
Madison River	45 16	111 41	1860.5	−19.00	0.00	−19.00		do.
Near Three Forks of Missouri	45 52	111 22	1860.5	−20.48	0.00	−20.48		do.
Yellowstone River	45 56	108 22	1860.5	−17.93	+0.05	−17.88		do.
Near Fort Union	47 56	104 02	1860.5	−19.93	+0.12	−19.81		do.
Head of Gallatin	45 15	111 00	1872.72	−19.15	0.00	−19.15	Hayden	Geol. Sur. Ter., 6th Ann. Rep.
Helena	46 36	111 53	1872.78	−19.98	0.00	−19.98	....do	do.
Bitter Root	47 19	115 04	1860.5	−20.75	−0.20	−20.95	Mullan	Stone's Mag. Var., 1878.
Hell Gate	46 52	113 59	1860.5	−21.00	−0.15	−21.15	....do	do.
Virginia City	45 19	111 56	1872.66	−19.25	0.00	−19.25	Hayden	Geol. Sur. Ter., 6th Ann. Rep.
NEBRASKA, PART 1.								
Omaha	41 16	95 56	1880.79	−10.10	....	−10.12		
NEBRASKA, PART 2.								
Nebraska City	40 42	95 52	1880.5	−10.22	+0.20	−10.02	Suter	Ch. of Eng's Rep., 1880.
Plattsmouth	41 01	95 53	1877.5	−11.25	+0.33	−10.92	Baisdell	Ch. of Eng's Rep., 1878.
Brownville	40 28	95 44	1877.5	−11.25	+0.33	−10.92	....do	do.
Niobrara River	42 34	103 57	1877.74	−15.45	+0.20	−15.25	Stanton	do.
Soldier's Creek	42 40	103 28	1877.75	−15.50	+0.20	−15.30	....do	do.
Indian Creek	42 59	104 03	1877.81	−16.65	+0.20	−16.45	....do	do.
Engineer's Cantonment	41 25	96 00	1819.72	−12.98	....	....	Long	Exp'n to Rocky Mts., 18
Sidney	41 08	102 55	1872.82	−14.62	+0.30	−14.32	Hilgard	Nat. Acad. Sc.
North Platte	41 11	100 45	1872.82	−13.12	+0.35	−12.77	do	do.
Grand Island	40 55	98 23	1872.82	−13.22	+0.43	−12.79	....do	do.
Rock Creek	40 11	97 02	1858.6	−12.10*	+1.00	−11.10	Simpson	Stone's Mag. Var., 1878.
Big Sandy River	40 12	97 12	1858.6	−13.65*	+1.00	−12.65	....do	do.
Little Blue River	40 15	98 10	1858.6	−13.72*	+0.90	−12.82	....do	do.
Elm Creek	40 30	98 30	1858.6	−12.30*	+0.85	−11.45	....do	do.
Fort Kearney	40 38	98 56	1858.7	−13.63*	+0.82	−12.81	....do	do.
Camp No. 2	40 40	99 54	1858.7	−13.28*	+0.75	−12.53	....do	do.
Platt River	40 58	100 35	1858.9	−13.53*	+0.70	−12.83	....do	do.
Camp No. 22	41 05	100 50	1858.7	−11.08*	+0.68	−10.40	....do	do.
Camp No. 25	41 03	101 50	1858.7	−13.35*	+0.58	−12.77	....do	do.
North Platte	41 23	102 15	1858.7	−15.43*	+0.53	−14.90	....do	do.
Grand Island	40 55	98 18	1878.66	−12.86	+0.25	−12.61	Thorpe	Proc. Roy. Soc., 18
North Platte	41 58	104 00	1858.7	−15.60*	+0.40	−15.20	Simpson	Stone's Mag. Var.
NEVADA, PART 1.								
Verdi	39 31	119 58	1872.51	−17.49	−0.10	−17.59		
Reno	39 30	119 49	1881.28	−17.81	−0.02	−17.83		
Hot Springs	39 47	118 56	1881.29	−17.44	−0.02	−17.46		
Rye Patch	40 26	118 18	1881.30	−17.83	−0.02	−17.85		
Winnemucca	40 59	117 44	1881.30	−17.65	−0.01	−17.66		
Battle Mountain	40 40	116 50	1881.31	−17.58	0.00	−17.58		
Elko	40 47	115 46	1881.32	−17.51	+0.01	−17.50		
Wells' Station	41 07	114 56	1881.32	−17.36	+0.02	−17.34		
Tecoma	41 20	114 06	1881.33	−17.47	+0.02	−17.45		
Eureka, town	39 31	115 58	1881.38	−16.61	+0.01	−16.60		
Mineral Hill	40 10	116 12	1881.39	−17.05	0.00	−17.05		
Austin	39 29	117 04	1881.41	−16.95	0.00	−16.95		
Mount Callahan	39 43	116 57	1881.53	−17.07	0.00	−17.07		
Eureka, trig. station	39 35	115 49	1881.70	−16.83	+0.01	−16.82		
White Pine	38 19	115 30	1881.88	−16.07	0.00	−16.07		

* An index correction of + 1° was applied to Simpson's observations.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
NEVADA, PART 2.	° ′	° ′		°	°	°		
Camp Halleck	40 49	115 20	1869.5	−16.36	−0.10	−16.46	Wheeler & Roberts	Ch. of Eng's Rep., 1876.
Camp Ruby	40 04	115 31	1869.5	−17.15	−0.10	−17.25	...do	do.
Hamilton	39 16	115 26	1869.5	−16.72	−0.10	−16.82	...do	do.
Monte Christo Mill	39 13	115 35	1869.5	−17.08	−0.10	−17.18	...do	do.
Antelope Springs	39 26	115 27	1869.5	−17.01	−0.10	−17.11	Wheeler & Lockwood.	do.
Benson's Creek	38 41	114 38	1869.5	−16.40	−0.10	−16.50	Wheeler	do.
Cave Valley	38 39	114 49	1869.5	−16.27	−0.10	−16.37	Wheeler & Lockwood.	do.
Clear Creek	38 50	114 25	1869.5	−16.44	−0.10	−16.54	Wheeler	do.
Clover Valley	37 30	114 14	1869.5	−14.42	−0.10	−14.52	Wheeler & Lockwood.	do.
Milo Hop Creek	38 23	114 30	1869.5	−16.00	−0.10	−16.10	Wheeler	Stone's Mag. Var., 1878.
Crescent Station	40 45	115 40	1869.5	−17.87	−0.10	−17.97	...do	do.
Cold Spring	40 04	115 42	1869.5	−17.21	−0.10	−17.31	...do	Ch. of Eng's Rep., 1876.
Homer Cedar Valley	38 03	114 10	1869.5	−17.67	−0.10	−17.77	...do	do.
Ice Creek	39 02	114 49	1869.5	−16.58	−0.10	−16.68	Wheeler & Lockwood.	do.
Indian Spring	36 34	115 35	1869.5	−15.69	−0.15	−15.84	Wheeler	do.
Mormon Cañon	37 16	114 28	1869.5	−16.58	−0.10	−16.68	Wheeler & Lockwood.	do.
Mud Spring	37 11	115 35	1869.5	−16.05	−0.15	−16.20	...do	do.
Murray Creek	39 15	114 51	1869.5	−16.59	−0.10	−16.69	...do	do.
Pearl Creek	40 17	115 44	1869.5	−16.31	−0.10	−16.41	...do	do.
Piermont	39 29	114 31	1872.5	−16.78	−0.05	−16.83	Hoxie	do.
Quinn Cañon	37 58	115 45	1869.5	−16.34	−0.15	−16.49	Wheeler & Lockwood.	do.
Rattlesnake Spring	38 57	114 26	1869.5	−16.30	−0.10	−16.40	...do	do.
Mouth of Rio Virgin	36 09	114 22	1869.5	−15.79	−0.10	−15.89	...do	do.
Rose Valley	37 55	114 16	1869.5	−17.84	−0.10	−17.94	...do	do.
Sacramento District	39 10	114 23	1869.5	−16.46	−0.10	−16.56	Wheeler	do.
Schafer Spring	37 34	115 27	1869.5	−16.18	−0.15	−16.33	Lockwood	do.
Sheep Range, Cedar Valley	38 14	114 22	1869.5	−16.77	−0.10	−16.87	Wheeler	do.
Slough, Long Valley	39 50	115 24	1869.5	−17.00	−0.10	−17.10	Wheeler & Lockwood.	do.
Huntingdon's Spring	40 01	115 19	1859.5	−17.60*	−0.20	−17.80	Simpson	Stone's Mag. Var., 1878.
Snake Valley	39 01	114 08	1872.5	−16.63	−0.05	−16.68	Hoxie	Ch. of Eng's Rep., 1876.
Spring below Panacea	37 46	114 27	1869.5	−16.98	−0.10	−17.08	Wheeler	do.
Saint Thomas	36 27	114 19	1869.5	−15.79	−0.10	−15.89	Wheeler & Lockwood.	do.
Vegas Wash	36 07	114 40	1869.5	−16.02	−0.10	−16.12	...do	do.
West Point	36 41	114 34	1869.5	−15.32	−0.10	−15.42	...do	do.
Willow Creek	40 31	115 44	1869.5	−17.45	−0.10	−17.55	...do	do.
Las Vegas Range	36 11	115 03	1869.5	−15.14	−0.15	−15.29	...do	do.
Stone Ferry	36 08	114 25	1875.6	−14.97	−0.05	−15.02	Bergland	do.
Antelope Valley	39 47	114 12	1859.5	−16.28*	−0.20	−16.48	Simpson	Stone's Mag. Var., 1878.
Eagan Cañon	39 52	114 58	1859.5	−16.28*	−0.20	−16.48	...do	do.
Cho-keep Pass	39 54	115 45	1858.9	−16.53*	−0.25	−16.78	...do	do.
Ko-bah Valley	39 44	116 10	1858.9	−16.23*	−0.25	−16.48	...do	do.
Reese River	39 29	117 03	1858.9	−16.55*	−0.30	−16.85	...do	do.
Carson Lake	39 24	118 30	1859.6	−16.68*	−0.35	−17.03	...do	do.
Big Bend, Walker River	39 09	118 56	1859.6	−16.43*	−0.35	−16.78	...do	do.
Genoa, Carson Valley	39 00	119 40	1859.6	−15.78*	−0.38	−16.16	...do	do.
NEW HAMPSHIRE, PART 1.								
Isle of Shoals	42 59	70 37	1847.62	+10.06	+2.61	+12.67		
Unkonoonuc	42 59	71 35	1848.77	+ 9.07	+2.52	+11.59		
Patuccawa	43 07	71 12	1849.63	+10.71	+2.45	+13.16		
Gunstock	43 31	71 22	1860.54	+10.90	+1.62	+12.52		
Troy	42 50	72 11	1861.64	+ 9.06	+1.56	+10.62		
Gorham	44 22	71 15	1873.73	+13.78	+0.58	+14.36		

* An index correction of + 0°.5 was applied to Simpson's observations.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	D	$D_{1885.0}$	Observer.	Reference.
NEW HAMPSHIRE, PART 1—Continued.	° ′	° ′		°	°	°		
Littleton	44 19	71 48	1873.74	+12.58	+0.72	+13.30		
Hanover, on hill and west of it	43 42	72 18	1879.76	+11.24	+0.42	+11.66		
NEW HAMPSHIRE, PART 2.								
Chesterfield	42 53	72 20	1837.5	+ 8.08	+3.38	+11.46	Twining	Sill. Jour., 1838.
Hinsdale	42 46	72 17	1772.5	+ 6.00	+5.10	+11.10	Wright	do.
Haverhill	44 02	72 05	1830.7	+ 7.53	+4.13	+11.66	Graham	Phil. Trans. Roy. Soc., 1849.
Warren	43 56	71 55	1830.7	+ 9.13	+3.75	+12.88	do	do.
West Romney	43 49	71 53	1830.7	+ 9.63	+3.75	+13.38	do	do.
Plymouth	43 45	71 42	1830.7	+ 8.53	+3.75	+12.28	do	do.
Fabyan Hotel	44 16	71 25	1845.47	+11.53	+2.38	+13.91	Locke	Smith'n Cont'ns, 1852.
Concord	43 12	71 29	1879.5	+11.45	+0.42	+11.87	McClintock	MS.
Lyman	44 13	71 54	1879.5	+11.55	+0.34	+11.89	do	MS.
NEW JERSEY, PART 1.								
Bergen Neck	40 46	74 03	1840.66	+ 5.88	+2.43	+ 8.31		
Mount Mitchell	40 24	74 00	1844.04	+ 5.66	+2.17	+ 7.83		
Sandy Hook	40 28	74 00	1879.54	+ 7.53	+0.24	+ 7.77		
Newark	40 45	74 10	1846.37	+ 5.58	+2.00	+ 7.58		
White Hill	40 08	74 44	1846.38	+ 4.43	+2.72	+ 7.15		
Church Landing	39 41	75 31	1846.43	+ 5.82	+2.72	+ 8.54		
Pine Mount	39 25	75 20	1846.46	+ 3.24	+2.52	+ 5.76		
Hawkins	39 26	75 17	1846.47	+ 2.98	+2.52	+ 5.50		
Port Norris	39 15	75 01	1846.48	+ 3.07	+2.52	+ 5.59		
Egg Island light	39 10	75 08	1846.48	+ 3.05	+2.52	+ 5.57		
Cape May light	38 56	74 58	1874.48	+ 4.63	+0.75	+ 5.38		
Townbank	38 59	74 58	1846.50	+ 2.98	+2.52	+ 5.50		
Pilottown	38 47	75 10	1846.50	+ 2.71	+2.52	+ 5.23		
Chew	39 48	75 10	1846.53	+ 3.75	+2.71	+ 6.46		
Old Inlet, Tucker Island	39 31	74 17	1846.86	+ 4.46	+2.69	+ 7.15		
Mount Rose	40 22	74 43	1852.62	+ 5.53	+2.38	+ 7.91		
Atlantic City	39 22	74 25	1860.64	+ 4.90	+1.90	+ 6.80		
Barnegat Light	39 46	74 06	1860.65	+ 5.40	+1.90	+ 7.30		
Long Beach	39 32	74 16	1860.65	+ 5.31	+1.90	+ 7.21		
NEW JERSEY, PART 2.								
Princeton	40 21	74 40	1810.5	+ 7.00	+4.57	+11.57	Smith	Sill. Jour., 1838.
Boundary Monument on Hudson	41 00	73 54	1774.7	+ 4.05	+3.53	+ 7.58	Cook	Rep. on Bound. Line, 1874.
Unionville	41 18	74 34	1874.60	+ 6.05	+0.44	+ 6.49	do	do.
Tri-States Rock	41 21	74 42	1874.60	+ 7.02	+0.60	+ 7.62	do	do.
Forked River	39 50	74 18	1876.5	+ 6.05	+0.74	+ 6.79	Moore	MS.
Jersey City	40 43	74 02	1841.1	+ 6.10	+2.40	+ 8.50	Douglass	Map of city.
NEW MEXICO TERRITORY, PART 1.								
NEW MEXICO TERRITORY, PART 2.								
Initial point, near El Paso del Norte.	31 47	106 28	1855.1	−11.92	−0.05	−11.97	Emory	Mex. Bound. Surv., 1856.
Carrizalillo	31 51	107 56	1855.2	−12.03	−0.10	−12.13	do	do.
Agua del Perro	31 21	108 20	1855.3	−11.97	−0.12	−12.09	do	do.
San Luis Springs	31 20	108 48	1855.3	−11.75	−0.15	−11.90	do	do.
Doña Aña	32 22	106 45	1851.5	−12.12	−0.10	−12.22	do	do.
Copper mines	32 48	108 04	1851.5	−14.37	−0.15	−11.52	do	do.
Abiquiu	36 12	106 19	1874.5	−13.90	+0.10	−13.80	Birnie	Ch. of Eng's Rep. 1876.
Coyote Creek	36 08	105 14	1874.5	−14.25	+0.10	−14.15	Blunt	do.
Fort Craig	33 38	107 01	1873.5	−12.99	+0.02	−12.97	Tillman	Ch. of Eng's Rep., 1879.
Fort Cummings	32 27	107 40	1873.5	−12.50	0.00	−12.50	do	Ch. of Eng's Rep., 1876.
Embuda	36 11	105 54	1874.5	−13.25	+0.10	−13.15	Birnie	do.
Line, Colorado and New Mexico	37 00	105 07	1873.5	−14.02	+0.10	−13.92	Marshall	do.
Mora River	35 59	105 19	1874.5	−14.67	+0.10	−14.57	Blunt	do.
Nutria Springs	35 18	108 33	1873.5	−14.27	0.00	−14.27	Hoxie	do.
Oak Spring	34 03	108 55	1873.5	−12.58	0.00	−12.58	do	do.
Ocate River	36 10	105 00	1874.5	−14.25	+0.10	−14.15	Blunt	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
NEW MEXICO TERRITORY, PART 2—Continued.	° ′	° ′		°	°	°		
Ojo Caliente Creek	36 17	106 02	1874.5	−13.25	+0.10	−13.15	Birnie	Ch. of Eng's Rep., 1879.
San Francisco River	33 12	108 52	1873.5	−13.52	0.00	−13.52	Hoxie	do.
do	33 26	108 55	1873.5	−13.82	0.00	−13.82	...do	do.
do	33 15	108 52	1873.5	−12.86	0.00	−12.86	...do	do.
Tierra Amarillo	36 42	106 33	1873.5	−13.71	+0.10	−13.61	Marshall	do.
Topographical camp	34 57	109 00	1873.5	−13.97	0.00	−13.97	Hoxie	do.
Tulerosa Fort	33 53	108 30	1873.5	−13.30	0.00	−13.30	...do	do.
Wermejo Creek	36 42	104 47	1874.5	−14.50	+0.12	−14.38	Blunt	do.
Water Hole	33 13	108 46	1873.5	−13.50	0.00	−13.50	Hoxie	do.
Fort Wingate	35 29	107 45	1873.5	−14.86	+0.05	−14.81	...do	do.
Albuquerque	35 06	106 38	1853.79	−13.42	0.00	−13.42	Ives	C. S. Rep., 1856.
Isleta	34 54	106 40	1853.85	−13.22	0.00	−13.22	...do	do.
Rio San José	35 01	107 14	1853.86	−13.77	0.00	−13.77	...do	do.
Covéro	35 05	107 26	1853.87	−13.82	−0.05	−13.87	...do	do.
Hay Camp	35 05	107 39	1853.87	−13.93	−0.05	−13.98	...do	do.
Agua Fria	35 02	107 58	1853.88	−13.42	−0.08	−13.50	...do	do.
Inscription Rock	35 03	108 14	1853.88	−12.95	−0.10	−13.05	...do	do.
Zuni River	35 06	108 39	1853.89	−13.40	−0.12	−13.52	...do	do.
Cedar Forest	35 01	108 55	1853.90	−13.02	−0.12	−13.14	...do	do.
Station in	35 40	106 50	1855.5	−13.67	0.00	−13.67		MS. on chart.
Initial point of New Mexico Meridian.	34 17	106 50	1855.3	−12.75	0.00	−12.75		do.
Fort Bascom	35 24	103 50	1856.5	−12.83	+0.10	−12.73		do.
Fort Sumner	34 25	104 08	1866.1	−13.75	+0.15	−13.60	Shinn	do.
Fort Stanton	33 30	105 32	1878.5	−12.40	+0.05	−12.35		Ch. of Eng's Rep., 1879.
Intersection point boundary	31 46	106 50	1855.7	−11.67	−0.05	−11.72		MS.
Espia	31 21	107 56	1855.5	−12.08	−0.10	−12.18	Emory	Phil. Trans. Roy. Soc., 1874.
Fort Bayard	32 48	108 09	1878.5	−12.93	0.00	−12.93		Ch. of Eng's Rep., 1879.
Fort Marcy, Santa Fé	35 41	105 57	1874.5	−13.16	+0.10	−13.06		do.
Fort Union	35 54	105 01	1874.5	−14.67	+0.10	−14.57		do.
NEW YORK, PART 1.								
Round Hill	41 06	73 40	1833.52	+ 5.72	+3.10	+ 8.82		
Buttermilk	41 07	73 49	1833.47	+ 3.93	+3.10	+ 7.03		
Bald Hill	41 13	73 29	1833.56	+ 5.57	+3.10	+ 8.67		
Howard	40 38	74 05	1840.49	+ 5.02	+2.44	+ 7.46		
New York, Columbia Coll. (old)	40 43	74 00	1845.68	+ 6.42	+2.04	+ 8.46		
New Rochelle	40 52	73 47	1844.69	+ 5.49	+2.40	+ 7.89		
Port Chester	41 00	73 40	1844.70	+ 5.97	+2.40	+ 8.37		
Manhattanville, Asylum	40 50	73 56	1846.33	+ 5.16	+2.00	+ 7.16		
Lloyd Harbor	40 56	73 25	1844.71	+ 6.19	+2.40	+ 8.59		
Oyster Bay	40 52	73 32	1844.71	+ 6.84	+2.40	+ 9.24		
Greenport	41 06	72 21	1845.63	+ 7.24	+2.63	+ 9.87		
Drowned Meadow	40 56	73 04	1845.70	+ 6.06	+2.63	+ 8.69		
Sand's Point	40 52	73 44	1847.77	+ 6.16	+1.89	+ 8.05		
Mount Prospect	40 40	73 58	1860.73	+ 6.73	+1.06	+ 7.79		
Cole	40 32	74 14	1846.35	+ 5.62	+1.99	+ 7.61		
Legget	40 49	73 54	1847.80	+ 5.68	+1.88	+ 7.56		
Greenbush	42 38	73 44	1855.66	+ 7.91	....	+10.19		
Coldspring	41 25	73 58	1855.66	+ 5.57	+1.68	+ 7.25		
New York, Governor's Island	40 42	74 01	1855.60	+ 6.66	+1.35	+ 8.01		
New York, Bedloe's Island	40 41	74 03	1855.60	+ 7.04	+1.35	+ 8.39		
New York, Rec. Res	40 47	73 58	1855.61	+ 6.47	+1.35	+ 7.82		
Albany, Dudley Observatory	42 40	73 45	1879.81	+ 9.86	....	+10.19		
Fire Island, West base	40 38	73 13	1860.66	+ 7.76	+1.07	+ 8.83		
Sag Harbor	41 00	72 17	1860.68	+ 8.46	+1.66	+10.12		
Ruland	40 51	73 02	1865.40	+ 7.51	+1.33	+ 8.84		
West Hills	40 49	73 26	1865.62	+ 7.02	+1.17	+ 8.19		
Carpenter's Point	41 21	74 42	1873.47	+ 7.08	+0.64	+ 7.72		
Duer	41 00	73 54	1873.62	+ 7.62	+0.47	+ 8.09		
Oxford	42 26	75 40	1874.42	+ 6.93	+0.80	+ 7.73		

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
NEW YORK, PART 1—Continued.	° ′	° ′		°	°	°		
Ithaca	42 28	76 33	1874.45	+ 5.43	+0.79	+ 6.22		
Potsdam	44 37	75 00	1874.79	+ 9.42	+0.82	+10.24		
Pierrepont Manor	43 44	76 04	1874.80	+ 6.20	+0.82	+ 7.02		
Clinton	43 03	75 24	1874.82	+ 8.09	+0.65	+ 8.74		
Patchogue	40 45	73 02	1875.59	+ 8.01	+0.63	+ 8.64		
Far Rockaway	40 36	73 46	1875.59	+ 7.20	+0.40	+ 7.60		
Babylon	40 42	73 20	1875,62	+ 7.58	+0.52	+ 8.10		
West Hampton	40 51	72 34	1875.64	+ 8.67	+0.63	+ 9.30		
East Hampton	40 58	72 12	1875.64	+ 9.09	+0.63	+ 9.72		
Montauk Point	41 04	71 51	1875.65	+ 9.75	+0.56	+10.31		
Sherburne	42 41	75 33	1875.67	+ 7.82	+0.65	+ 8.47		
Rouse's Point	45 00	73 21	1879.75	+13.65	+0.42	+14.07		
NEW YORK, PART 2.								
Troy	42 44	73 40	1827.5	+ 6.08	+3.96	+10.04	Silliman	Sill. Jour., 1830.
Ancram	42 06	73 37	1853.5	+ 7.65	+2.18	+ 9.83	Hogeboom	Geol. Sur. of N. Y.
Auburn	42 55	76 28	1833.82	+ 3.72	+3.80	+ 7.52	Regents' Rep	do.
Canajoharie	42 53	74 35	1839.80	+ 6.08	+3.21	+ 9.29	do	do.
Cazenovia	42 55	75 51	1843.47	+ 3.87	+3.04	+ 6.91	do	do.
Cherry Valley	42 48	74 47	1839.63	+ 5.22	+3.25	+ 8.47	do	do.
Delaware River	42 00	75 58	1774.5	+ 4.33	+3.53	+ 7.86	Rittenhouse	do.
Dunkirk	42 29	79 23	1845.5	+ 1.12	+2.97	+ 4.09	U. S. Top. Eng's	Chart of Lake Erie.
East Hampton	41 00	72 19	1834.84	+ 6.13	+3.23	+ 9.36	Regents' Rep	Geol. Sur. of N. Y.
Geneva	42 52	77 05	1833.75	+ 3.82	+3.80	+ 7.62	do	do.
Guilford	42 24	75 37	1838.51	+ 4.50	+3.36	+ 7.86	do	do.
Hamilton	42 49	75 34	1837.8	+ 4.50	+3.42	+ 7.92	do	do.
Homer	42 38	76 11	1840.81	+ 5.08	+3.22	+ 8.30	do	do.
Jamaica	40 41	73 56	1835.5	+ 4.00	+2.99	+ 6.99	do	Am. Jour. of Sc. & Arts, xxxiv.
Johnstown	43 00	74 23	1818.90	+ 6.03	+4.32	+10.35	do	Geol. Sur. of N. Y.
Lake Champlain	45 00	73 54	1774.8	+ 9.00	+5.30	+14.30	Collins	do.
New Pre-emption line	42 00	77 06	1795.5	+ 1.92*	+4.68	+ 6.60	Ellicott	do.
do	42 05	77 06	1795.5	+ 1.33*	+4.68	+ 6.01	do	do.
do	42 07	77 06	1795.5	+ 1.83*	+4.68	+ 6.51	do	do.
do	42 12	77 06	1795.5	+ 2.42*	+4.68	+ 7.10	do	do.
do	42 20	77 06	1795.5	+ 1.71*	+4.68	+ 6.39	do	do,
do	42 28	77 06	1795.5	+ 1.92*	+4.68	+ 6.60	do	do.
do	42 32	77 06	1795.5	+ 1.50*	+4.68	+ 6.18	do	do.
do	42 36	77 06	1795.5	+ 2.08*	+4.68	+ 6.76	do	do.
do	42 41	77 06	1795.5	+ 1.75*	+4.68	+ 6.43	do	do.
do	42 52	77 06	1795.5	+ 1.50*	+4.68	+ 6.18	do	do.
do	43 03	77 06	1795.5	+ 2.08*	+4.68	+ 6.76	do	do.
New Pre-emption line (Lake Ontario).	43 10	77 06	1795.5	+ 1.92*	+4.68	+ 6.60	do	do.
North Salem	41 26	73 38	1843.5	+ 6.00	+2.48	+ 8.48	Regents' Rep	do.
Oblong	42 03	73 30	1786.5	+ 5.05	+3.65	+ 8.70	Williams	do.
Ogdensburg	44 43	75 34	1838.5	+ 6.17	+3.73	+ 9.90	Regents' Rep	do.
Pennsylvania line	42 00	75 55	1786.5	+ 3.53	+4.68	+ 8.21	De Witt and others	do.
do	42 00	76 16	1786.5	+ 3.67	+4.68	+ 8.35	do	do.
do	42 00	76 45	1786.5	+ 1.83	+4.48	+ 6.31	do	do.
do	42 00	77 16	1786.8	+ 2.50	+4.20	+ 6.70	do	do.
do	42 00	77 38	1786.5	+ 1.87	+3.96	+ 5.83	do	do.
do	42 00	78 15	1786.5	+ 0.75	+3.73	+ 4.48	do	do.
do	42 00	78 50	1786.5	+ 1.50	+3.35	+ 4.85	do	do.
do	42 00	79 20	1786.5	+ 0.92	+3.25	+ 4.17	do	do.
do	42 00	79 58	1786.5	+ 0.53	+3.25	+ 3.78	do	do.
do	42 00	80 30	1787.80	+ 0.12	+3.30	+ 3.42	do	do.
Rochester	43 07	77 39	1876.5	+ 5.68	+0.70	+ 6.38	Nichols	MS.
Utica	43 06	75 13	1836.0	+ 3.88	+3.50	+ 7.38	Regents' Rep	Sill. Jour., 1838.
West Point	41 25	73 56	1835.7	+ 6.53	+2.78	+ 9.31	Davies	Geol. Sur. of N. Y.
Fort Erie	42 54	78 59	1839.5	+ 1.25	+3.48	+ 4.73	Chart	U. S. Lake Sur.
Fort Niagara	43 15	79 04	1864.5	+ 3.02	+1.72	+ 4.74		Sur. of N. and N. W. Lakes (MS.)

*An index correction of —1°.5 was applied to these observations.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1888.0}$	Observer.	Reference.
NEW YORK, PART 2—Continued.	° ′	° ′		°	°	°		
Charlotte	43 13	77 51	1873.41	+ 3.77	+0.96	+ 4.73	Lee	Sur. of N. and N. W. Lakes (MS.)
Sackett's Harbor	43 57	76 07	1873.40	+ 8.25	+0.95	+ 9.20	....do	do.
Monroe	41 21	74 11	1859.5	+ 6.63	+1.12	+ 7.75	Brooks	MS.
Schenectady	42 49	73 55	1859.2	+ 7.96	+1.75	+ 9.71	....do	MS.
Lowville	43 48	75 35	1821.5	+ 4.50	+4.88	+ 9.38	Clark	MS.
Plessis	44 16	75 55	1858.4	+ 7.58	+2.02	+ 9.60	....do	MS.
Oswego	43 25	76 34	1797.5	+ 3.00	+4.71	+ 7.71	De Witt	MS.
Owego	42 06	76 16	1868.5	+ 5.37	+1.20	+ 6.57	Camp	MS.
Oneida County	43 16	75 15	1794.46	+ 3.97	+4.75	+ 8.72	Pharoux	Regents' Rep., 1869.
Jefferson County	44 09	75 37	1794.60	+ 2.67	+4.86	+ 7.53	....do	do.
Champlain, near Rouse's Point	45 00	73 26	1838.5	+ 9.50	+4.27	+13.77	Geol. Rep	Sill. Jour., 1840.
West Chazy	44 52	73 25	1838.5	+ 9.35	+4.03	+13.38	... do	do.
Keeseville	44 28	73 32	1838.5	+ 8.67	+3.58	+12.25	.. do	do.
Rossie	44 22	75 43	1839.5	+ 6.72	+3.38	+10.10	Hopkins	do.
Dial Mountain	44 21	73 49	1838.5	+ 8.34	+3.58	+11.92	Geol. Rep	do.
Niagara Falls	43 04	79 04	1874.58	+ 3.62	+0.86	+ 4.48	Hilgard	Nat. Acad. Sc.
East Moriah and Cedar Point	44 03	73 30	1838.5	+ 9.82	+3.96	+13.78	Geol. Rep	Sill. Jour., 1840.
West Moriah and Small Pond	44 02	73 39	1838.5	+ 7.16	+3.96	+11.12	....do	do.
Near the Mountain	44 01	73 50	1838.5	+ 8.27	+3.96	+12.23	.. do	do.
Crown Point	43 55	73 27	1838.5	+ 8.78	+3.96	+12.74	....do	do.
Warrensburg	43 26	73 45	1838.5	+ 7.25	+3.82	+11.07	....do	do.
Ways Reef, Hell Gate	40 46	73 56	1874.6	+ 7.38	+0.44	+ 7.82	Newton	Ch. of Eng's Rep., 1875.
Holland Land Company	42 39	78 13	1799.5	+ 0.45	+4.68	+ 5.13	Dewey	Regents' Rep., 1869.
do	42 51	78 11	1799.5	+ 1.08	+4.68	+ 5.76	... do	do.
do	42 50	78 19	1799.5	+ 0.35	+4.68	+ 5.03	....do	do.
Tonawanda Reservation	43 04	78 22	1799.1	+ 1.50	+4.67	+ 6.17	Thompson	do.
Old Kena-andoa	42 27	78 00	1798.5	+ 1.00	+4.66	+ 5.66	Porter	do.
Gardeau Reservation	42 38	77 51	1798.68	+ 1.58	+4.66	+ 6.24	....do	do.
On Lake Ontario	43 21	78 01	1799.5	+ 1.00	+4.68	+ 5.68	Atwater	do.
Holland Land Company	42 19	79 09	1798.5	— 0.75	+4.18	+ 3.43	....do	do.
do	42 31	79 03	1798.5	— 0.85	+4.35	+ 3.50	....do	do.
do	42 13	78 10	1799.0	+ 0.86	+4.67	+ 5.53	Atwater & Benton	do.
do	42 30	78 06	1798.5	+ 1.13	+4.66	+ 5.79	Atwater	do.
do	42 43	78 13	1798.5	+ 0.62	+4.66	+ 5.28	....do	do.
do	42 20	78 40	1799.5	+ 1.45	+4.37	+ 5.82	....do	do.
Gorham Purchase	42 36	78 03	1798.5	+ 0.87	+4.66	+ 5.53	Burgess	do.
do	43 08	78 01	1798.5	+ 1.03	+4.66	+ 5.69	....do	do.
Holland Land Company	42 10	78 15	1798.5	+ 1.15	+4.66	+ 5.81	Porter	do.
do	43 16	78 43	1799.5	+ 0.50	+4.68	+ 5.18	Benton	do.
do	42 10	78 23	1798.5	+ 1.02	+4.66	+ 5.68	Smedley	do.
do	42 15	78 22	1798.5	+ 1.20	+4.66	+ 5.86	....do	do.
do	42 39	78 23	1798.5	+ 1.90	+4.66	+ 6.56	....do	do.
Ellicottville	42 18	78 44	1841.62	+ 2.60	+3.47	+ 7.07	Bache	C. S. Rep., 1862.
Silver Lake	41 57	76 02	1841.64	+ 4.50	+3.16	+ 7.66	....do	do.
Madalin	42 03	73 54	1878.00	+ 8.77	+0.42	+ 9.19	Cooke	MS.
Bath	42 21	77 21	1874.56	+ 5.57	+0.81	+ 6.38	Hilgard	Nat. Acad. Sc.
Mayville	42 16	79 40	1874.59	+ 2.25	+0.73	+ 2.98	....do	do.
Crown Point	44 02	73 25	1879.5	+ 9.62	+0.53	+10.15	Colvin	Adir. Sur. 7th Ann. Rep.
Bald Peak	44 06	73 29	1879.5	+11.99	+0.53	+12.52	....do	do.
Mount Hurricane	44 14	73 42	1879.5	+ 9.15	+0.55	+ 9.70	....do	do.
Mount Dix	44 05	73 47	1879.5	+ 9.96	+0.55	+10.51	....do	do.
Mount Marcy	44 07	73 55	1879.5	+10.71	+0.55	+11.26	....do	do.
Whiteface Mountain	44 22	73 54	1879.5	+10.99	+0.55	+11.54	....do	do.
Saint Regis Mountain	44 24	74 20	1879.5	+10.52	+0.55	+11.07	....do	do.
Norway Mountain	44 34	73 41	1879.5	+12.27	+0.55	+12.82	....do	do.
Lyon Mountain	44 42	73 52	1879.5	+12.44	+0.55	+12.99	....do	do.
Rand Hill	44 46	73 36	1879.5	+11.34	+0.55	+11.89	....do	do.
La Motte	44 50	73 20	1879.5	+13.36	+0.55	+13.91	....do	do.
Helderberg	42 38	74 01	1877.7	+ 8.75	+0.44	+ 9.19	Gardner	N. Y. State Sur. Rep., 1879.
Cass and Clarksville	42 34	73 58	1877.9	+ 8.75	+0.43	+ 9.18	....do	do.
Freleigh and Niskayuna	42 46	73 48	1877.9	+ 9.62	+0.43	+10.05	....do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
NEW YORK, PART 2—Continued.	° ′	° ′		°	°	°		
Knowersville and Winn	42 43	74 02	1877.9	+ 8.88	+0.43	+ 9.31	Gardner	N. Y. State Sur. Rep., 1879.
Slingerland	42 38	73 52	1877.9	+ 8.75	+0.43	+ 9.18	...do	do.
Tanner	43 01	76 34	1878.5	+ 3.82	+0.49	+ 4.31	...do	do.
Allis and Canastota	43 05	75 46	1879.5	+ 7.52	+0.39	+ 7.91	...do	do.
Bulger and Cranson	43 02	75 43	1879.5	+ 7.27	+0.39	+ 7.66	...do	do.
Eaton	43 02	75 33	1879.5	+ 7.93	+0.39	+ 8.32	...do	do.
Rome	43 14	75 28	1879.5	+ 7.87	+0.39	+ 8.26	...do	do.
Vienna	43 15	75 41	1879.5	+ 8.40	+0.39	+ 8.79	...do	do.
Clapp	42 58	76 02	1878.6	+ 7.20	+0.45	+ 7.65	...do	do.
Collamer	43 06	76 04	1879.5	+ 7.33	+0.39	+ 7.72	...do	do.
Cossitt	43 00	76 12	1878.6	+ 6.77	+0.45	+ 7.22	...do	do.
Davison	43 06	76 17	1878.6	+ 6.57	+0.45	+ 7.02	...do	do.
Eagle	43 01	75 55	1878.6	+ 7.28	+0.45	+ 7.73	...do	do.
Green	42 59	76 02	1878.6	+ 6.98	+0.45	+ 7.43	...do	do.
Hoxsie and Seeley	42 57	76 22	1878.6	+ 6.33	+0.45	+ 6.78	...do	do.
Kirkville	43 04	75 56	1879.5	+ 7.05	+0.39	+ 7.44	...do	do.
Conover and Chapman	42 47	74 15	1877.9	+ 9.00	+0.42	+ 9.42	...do	do.
Van Atten	42 54	74 00	1877.9	+10.25	+0.42	+10.67	...do	do.
Sears and Mann	42 42	74 17	1877.9	+ 9.12	+0.42	+ 9.54	...do	do.
Summit and Holmes	42 37	74 33	1877.9	+ 8.88	+0.42	+ 9.30	...do	do.
Clyde	43 03	76 52	1878.5	+ 5.72	+0.49	+ 6.21	...do	do.
Milo	42 35	77 02	1878.5	+ 7.25	+0.49	+ 7.74	...do	do.
Vedder	43 01	74 39	1880.7	+ 9.13	+0.25	+ 9.38	...do	N. Y. State Sur. Rep., 1880.
Lampman	42 20	73 48	1880.7	+ 9.37	+0.25	+ 9.62	...do	do.
Barto	43 08	74 53	1879.6	+ 9.52	+0.32	+ 9.84	...do	do.
Getman, Herkimer, and Jackson	43 02	75 00	1879.6	+ 8.43	+0.32	+ 8.75	...do	do.
Little Falls	43 03	74 52	1880.7	+ 7.35	+0.25	+ 7.60	...do	do.
Merry	43 03	75 10	1879.6	+ 8.63	+0.32	+ 8.95	...do	do.
Ostrander	42 57	74 48	1880.7	+ 9.10	+0.25	+ 9.35	...do	do.
Schuyler	43 10	75 07	1879.6	+ 8.93	+0.32	+ 9.25	...do	do.
Shoemaker and Yule	42 58	74 54	1879.6	+ 8.54	+0.32	+ 8.86	...do	do.
Nellis, Reinan, and Willett	42 57	74 38	1880.8	+ 9.10	+0.25	+ 9.35	...do	do.
Oak Ridge	42 47	74 19	1880.8	+ 9.27	+0.25	+ 9.52	...do	do.
Prospect	43 02	75 27	1879.5	+ 8.58	+0.32	+ 8.90	...do	do.
Tassel	42 56	75 19	1879.6	+ 8.15	+0.32	+ 8.47	...do	do.
Williams	43 10	75 13	1879.6	+ 8.97	+0 32	+ 9.29	...do	do.
NORTH CAROLINA, PART 1.								
Bodies Island	35 48	75 32	1846.99	+ 1.22	+2.26	+ 3.48		
Stevenson's Point	36 06	76 11	1847.10	+ 1.66	+2.26	+ 3.92		
Shellbank	36 04	75 44	1847.24	+ 1.75	+2.25	+ 4.00		
Raleigh	35 47	78 38	1854.02	— 0.74	+1.87	+ 1.13		
Wilmington	34 14	77 57	1854.42	— 1.22	+1.83	+ 0.61		
Fort Johnson	33 55	78 01	1874.99	+ 0.40	+0.56	+ 0.96		
Portsmouth Island	35 04	76 03	1871.25	+ 2.37	+0.82	+ 3.19		
New Berne	35 07	77 03	1874.98	+ 1.34	+0.58	+ 1.92		
Sand Island	35 50	75 40	1876.08	+ 2.98	+0.48	+ 3.46		
Beaufort	34 43	76 40	1880.03	+ 1.74	+0.29	+ 2.03		
NORTH CAROLINA, PART 2.								
Greensborough	36 04	79 40	1873.57	— 0.72	+0.72	0.00	Hilgard	Nat. Acad. Sc.
Salisbury	35 40	80 20	1873.58	— 0.87	+0.67	— 0.20	...do	do.
Charlotte	35 14	80 40	1873.58	— 1.06	+0.67	— 0.39	...do	do.
Morgantown	35 47	81 30	1873.59	— 1.18	+0.67	— 0.51	...do	do.
Asheville	35 35	82 30	1873.60	— 1.97	+0.67	— 1.30	...do	do.
Goldsborough	35 25	77 50	1875.49	+ 0.25	+0.57	+ 0.82	Poole	do.
Weldon	36 27	77 25	1875.49	+ 1.68	+0.60	+ 2.28	...do	do.
OHIO, PART 1.								
South Point	38 25	82 35	1864.14	— 1.88	+1.38	— 0.50		
Cleveland	41 30	81 42	1880.52	+ 1.64	....	+ 1.51		
Cincinnati, observatory	39 09	84 25	1880.91	— 2.24	....	— 1.95		
Athens	39 20	82 02	1880.93	— 0.68	+0.28	— 0.40		

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
OHIO, PART 2.	° ′	° ′		°	°	°		
Ashtabula	41 55	80 47	1865.5	− 0.01	+1.13	+ 1.12		MS.
Huron Light	41 24	82 33	1845.5	− 2.17	+1.85	− 0.32	Chart	Sur. of Lakes.
West Sister	41 44	83 06	1847.5	− 2.33	+1.75	− 0.58	...do	do.
Kelly and Bass Islands	41 37	82 43	1846.5	− 2.30	+1.80	− 0.50	Chart and U. S. Top. Eng's.	Sur. of Lakes and U. S. C. S. Rep., 1856.
Tuscarawas	40 24	81 50	1874.63	+ 0.33	+0.58	+ 0.91	Hilgard	Nat. Acad. Sc.
Chillicothe	39 21	82 54	1835.5	− 3.25	+2.85	− 0.40	Bourne	MS. by Whittlesey.
Springfield	39 54	83 47	1835.5	− 4.50	+2.73	− 1.77	Dutton	do.
Western Reserve, southeast corner or Poland.	41 00	80 37	1810.5	− 1.35	+3.20	+ 1.85	Mansfield	Sill. Jour., 1838.
On Pennsylvania line	41 29	80 37	1796.59	− 1.62	+3.52	+ 1.90	Halley	MS. by Whittlesey.
do	41 49	80 37	1796.6	− 1.38	+3.52	+ 2.14	Halley & Porter	do.
Youngstown	41 12	80 46	1796.6	− 1.45	+3.45	+ 2.00	Spofford	do.
Denmark	41 47	80 45	1796.69	− 1.50	+3.52	+ 2.02	Denmark	do.
Bloomfield	41 43	81 00	1796.63	− 2.00	+3.45	+ 1.45	Pease	do.
Mesopotamia	41 29	81 00	1796.64	− 2.37	+3.45	+ 1.08	...do	do.
Newberry and Aurora	41 26	81 18	1796.66	− 1.35	+3.45	+ 2.10	...do	do.
Kirtland and Mentor	41 42	81 22	1796.66	− 1.42	+3.45	+ 2.03	Pease & Halley	do.
Mayfield	41 32	81 26	1796.66	− 1.05	+3.45	+ 2.40	Pease	do.
Streetsborough	41 17	81 22	1821.4	− 2.08	+2.87	+ 0.79	Cowles	do.
Willoughby	41 40	81 29	1796.7	− 1.83	+3.44	+ 1.61	Halley	do.
Akron and Tallmadge	41 08	81 31	1802.2	− 1.50	+3.37	+ 1.87	Warren, Atwater, Ensign.	do.
East Sister Isle	41 49	82 51	1847.5	− 2.30	+1.91	− 0.39	U. S. Top. Eng's.	C. S. Rep., 1856.
Hudson	41 15	81 26	1840.5	− 0.87	+2.10	+ 1.23	Loomis	C. S. Rep., 1855.
Carrolton, Montgomery County	39 38	84 09	1845.7	− 4.76	+2.33	− 2.43	Locke	do.
Oxford	39 30	84 38	1845.6	− 4.83	+2.33	− 2.50	...do	do.
Conneaut	41 58	80 32	1865.5	− 0.83	+1.13	+ 0.30		Sur. of Lakes.
Fairport	41 45	81 15	1865.5	− 0.82	+0.86	+ 0.04		MS. by Reynolds.
Black River	41 29	82 09	1865.5	− 1.60	+0.86	− 0.74		do.
Sandusky	41 28	82 42	1864.5	− 1.72	+1.00	− 0.72		U. S. Lake Sur.
Rapids of Maumee	41 30	83 30	1810.5	− 2.80	+3.47	+ 0.67	Mansfield	Sill. Jour., 1838.
Defiance	41 15	84 23	1810.5	− 4.50	+3.47	− 1.03	...do	do.
Canfield	41 00	80 50	1810.5	− 1.62	+3.19	+ 1.57	...do	do.
Berlin	41 00	81 03	1810.5	− 1.80	+3.19	+ 1.39	...do	do.
Atwater	41 00	81 21	1810.5	− 2.07	+3.19	+ 1.12	...do	do.
Suffield and Portage	41 00	81 32	1824.5	− 1.81	+2.78	+ 0.97	Mansfield & Mallison.	Sill. Jour., 1838 and 1840.
Coventry	41 00	81 48	1810.5	− 2.32	+3.19	+ 0.87	Mansfield	Sill. Jour., 1838.
Norton	41 00	81 53	1810.5	− 2.50	+3.19	+ 0.69	...do	do.
Seneca	41 00	83 20	1810.5	− 3.95	+3.24	− 0.71	...do	do.
Chippewa	40 55	81 48	1810.5	− 2.60	+3.19	+ 0.59	...do	do.
Marietta and near Marietta	39 28	81 26	1838.5	− 1.54	+1.99	+ 0.45	Loomis & Stone	Sill. Jour., 1838 and 1840.
Mouth of Miami River	39 08	84 45	1810.5	− 5.17	+3.05	− 2.12	Mansfield	Sill. Jour., 1838.
Portsmouth	38 48	82 50	1805.5	− 5.00	+3.20	− 1.80	Pub. surveys	do.
Chardon	41 35	81 15	1838.5	− 0.25	+2.19	+ 1.94	Cowles	Sill. Jour., 1840.
Euclid	41 34	81 32	1825.5	− 1.50	+2.74	+ 1.24	Merchant	do.
Lower Sandusky	41 21	83 09	1838.5	− 2.80	+2.54	− 0.26	De Reeves	do.
Flat Rock	41 18	84 12	1838.5	− 3.23	+2.54	− 0.69	Brownell	do.
Brookfield	41 14	80 37	1837.5	− 0.67	+2.24	+ 1.57	Boyse	do.
Braceville	41 14	81 03	1838.5	− 0.83	+2.19	+ 1.36	Stowe	do.
Kalida	40 59	84 14	1838.5	− 3.00	+2.58	− 0.42	Fitch	do.
Wooster	40 49	81 58	1840.5	− 1.78	+2.10	+ 0.32	Christmas	do.
Kenton	40 39	83 37	1838.5	− 5.28	+2.58	− 2.70	Ross	do.
Sandy	40 37	81 28	1810.5	− 2.17	+3.12	+ 0.95	Buckingham	do.
Carrolton, Carroll County	40 36	81 09	1838.5	− 0.50	+2.52	+ 2.02	Van Brown	do.
Marion	40 35	83 09	1838.5	− 3.28	+2.41	− 0.87	Holmes	do.
Dover	40 31	81 29	1838.5	− 1.83	+2.52	+ 0.69	Beeson	do.
Coshocton	40 28	81 57	1838.5	− 1.50	+2.52	+ 1.02	Sweeny	do.
Saint Clairsville	40 10	80 52	1838.5	− 2.52	+2.52	0.00	Moore	do.
Zanesville	39 58	82 04	1838.5	− 2.50	+2.84	+ 0.34	Boyle	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
OHIO, PART 2—Continued.	° ′	° ′		°	°	°		
Batesville	39 58	81 11	1838.5	− 1.37	+2.84	+ 1.47	Atkinson	Sill. Jour., 1840.
New Madison	39 56	84 37	1838.5	− 4.85	+2.62	− 2.23	Jaqua	do.
Washington	39 34	83 21	1838.5	− 3.10	+2.62	− 0.48	Bell	do.
Springborough	39 31	84 16	1838.5	− 4.07	+2.62	− 1.45	Baily	do.
Wilmington	39 28	83 42	1838.5	− 4.08	+2.62	− 1.46	Wickersham	do.
Jackson	39 15	82 42	1838.5	− 3.17	+2.73	− 0.44	Tyson	do.
Gallipolis	38 53	82 07	1838.5	− 2.58	+2.73	+ 0.15	Fletcher	do.
Columbus	39 57	82 59	1874.63	− 1.20	+0.56	− 0.64	Hilgard	Nat. Acad. Sc.
Forest	40 50	83 28	1874.64	− 2.30	+0.61	− 1.69	....do	do.
New Lisbon	40 50	80 49	1880.5	+ 1.48	+0.22	+ 1.70	Strawn	MS.
Ohio and Pennsylvania State line.	40 53	80 36	1880.4	+ 1.92	+0.22	+ 2.14	....do	MS.
OREGON, PART 1.								
Ewing Harbor	42 44	124 30	1851.89	−18.50	−1.20	−19.70		
Koos Bay	43 24	124 17	1863.53	−18.62	−0.74	−19.36		
Astoria	46 12	123 50	1881.61	−22.44	−0.13	−22.57		
Portland	45 32	122 42	1881.59	−22.20	−0.13	−22.33		
Jacksonville	42 18	122 58	1881.54	−17.41	−0.10	−17.51		
Canyonville	42 54	123 18	1881.55	−17.81	−0.10	−17.91		
Oakland	43 26	123 18	1881.56	−19.69	−0.10	−19.79		
Eugene	44 03	123 00	1881.56	−20.80	−0.12	−20.92		
Albany	44 39	123 02	1881.57	−21.70	−0.12	−21.82		
Salem	44 56	122 58	1881.58	−19.97	−0.12	−20.09		
Saint Helens	45 52	122 48	1881.62	−19.13	−0.13	−19.26		
Umatilla	45 57	119 20	1881.76	−21.54	−0.10	−21.64		
Blalock	45 44	120 15	1881.77	−20.35	−0.12	−20.47		
Three Mile Creek, near Dalles	45 39	120 58	1881.78	−21.05	−0.12	−21.17		
OREGON, PART 2.								
Cape Blanco, near	43 06	124 18	1792.31	−16.00	−3.70	−19.70	Vancouver	Hansteen's Erdmag.
Cape Foulweather, near	44 42	124 07	1792.31	−18.00	−3.68	−21.68	....do	do.
Cape Lookout, near	45 15	124 30	1789.51	−16.08	−3.75	−19.83	Meares	Narr. describing the coast.
Fort Dalles	45 34	120 56	1859.42	−19.75	−0.75	−20.50	Dixon	Sen. Pub. Doc. vol. 9, 1859–'60.
Oak Grove Creek	45 06	121 05	1859.44	−19.33	−0.75	−20.08	....do	do.
Crossing of the Des Chutes	44 47	120 50	1859.44	−19.25	−0.75	−20.00	....do	do.
Willow Creek	44 27	120 43	1859.47	−18.92	−0.75	−19.67	....do	do.
Crooked River Cañon	44 03	119 50	1859.49	−18.67	−0.70	−19.37	....do	do.
Lake Whatumpi	43 16	119 05	1859.51	−18.17	−0.65	−18.82	....do	do.
Stillwater Slough	43 25	118 38	1859.52	−18.17	−0.60	−18.77	....do	do.
Surprise Creek	43 37	118 38	1859.52	−18.42	−0.60	−19.02	....do	do.
Rock Creek Cañon	43 56	117 57	1859.53	−18.50	−0.50	−19.00	....do	do.
Malheur River	43 49	117 10	1859.54	−18.25	−0.40	−18.65	....do	do.
Ford of Owyhee River	43 47	116 48	1859.71	−18.07	−0.40	−18.47	....do	do.
Birch Creek, Snake River	44 16	117 16	1859.73	−18.15	−0.40	−18.55	....do	do.
Grand Rond Valley	45 16	117 33	1859.75	−18.33	−0.45	−18.78	....do	do.
Grand Rond River	45 20	117 47	1859.75	−19.00	−0.45	−19.45	....do	do.
Lee's Encampment, Blue Mountains.	45 33	118 21	1859.75	−19.33	−0.55	−19.88	....do	do.
Umatilla River, near McKay's Agency.	45 41	118 40	1859.77	−20.04	−0.60	−20.64	....do	do.
Camp Harney	43 00	119 00	1876.1	−18.38	−0.65	−19.03	Wainwright	Ch. of Engs. Rep., 1876.
PENNSYLVANIA, PART 1.								
Girard College, Philadelphia	39 58	75 10	1877.76	+ 6.04	....	+ 6.70		
Bristol	40 07	74 53	1846.52	+ 4.46	+2.72	+ 7.18		
Yard	39 58	75 23	1854.82	+ 6.70	+2.25	+ 8.95		
Harrisburg	40 16	76 53	1877.73	+ 4.89	....	+ 5.30		
Johnson's Tavern	40 00	79 48	1862.58	+ 1.23	+1.16	+ 2.39		
Bethlehem	40 38	75 18	1874.47	+ 5.32	+0.90	+ 6.22		
PENNSYLVANIA, PART 2.								
Westchester	39 57	75 40	1878.3	+ 5.87	+0.47	+ 6.34	County Surveyors.	Ann. Rep. Sec. Int. Aff., 1878.
Erie	42 08	80 05	1877.9	+ 3.00	....	+ 3.39	....do	Ann. Rep. Sec. Int. Aff., 1877.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
PENNSYLVANIA, PART 2—Cont'd.	° ′	° ′		°	°	°		
Heiner's Run	41 21	77 48	1856. 5	+ 3. 32	+1. 92	+ 5. 24	Tyndale	C. S. Rep. for 1856.
Pittsburg	40 27	79 59	1845. 33	+ 0. 55	....	+ 2. 72	Locke	C. S. Rep. for 1855.
Beaver	40 44	80 16	1874. 61	+ 1. 14	+0. 59	+ 1. 73	Hilgard	Nat. Acad. Sc.
West Boundary of State	41 08	80 37	1786. 5	— 0. 42	+3. 38	+ 2. 96	Ellicott	Sill. Jour., 1838.
do	40 50	80 37	1786. 5	— 0. 28	+3. 38	+ 3. 10	....do	do.
do	40 42	80 37	1786. 5	— 0. 85	+3. 38	+ 2. 53	....do	do.
do	40 14	80 37	1786. 5	— 1. 12	+3. 38	+ 2. 26	....do	do.
do	39 59	80 37	1786. 5	— 1. 20	+3. 38	+ 2. 18	....do	do.
do	39 51	80 37	1786. 5	— 2. 17	+3. 38	+ 1. 21	....do	do.
Norristown	40 07	75 19	1855. 29	+ 4. 73	+2. 22	+ 6. 95	County Surveyors	Ann. Rep. Sec. Int. Aff., 1876.
Fairview	42 05	80 27	1838. 5	0. 00	+3. 12	+ 3. 12	Sherwood	Sill. Jour., 1840.
Hatboro'	40 12	75 07	1850. 5	+ 4. 42	+2. 50	+ 6. 92	Beans	MS.
Huntingdon	40 30	78 02	1874. 6	+ 3. 57	+0. 57	+ 4. 14	County Surveyors	Ann. Rep. Sec. Int. Aff., 1876.
Irwin's Mill	39 47	77 56	1840. 65	+ 0. 91	+2. 86	+ 3. 77	Bache	C. S. Rep., 1862.
Easton	40 42	75 15	1841. 56	+ 3. 63	+2. 99	+ 6. 62	....do	do.
Williamsport	41 15	77 03	1878. 5	+ 5. 25	+0. 38	+ 5. 63	County Surveyors	Ann. Rep. Sec. Int. Aff., 1878.
Curwinsville	40 58	78 36	1841. 58	+ 1. 75	+2. 75	+ 4. 50	Bache	C. S. Rep., 1862.
Mercer	41 14	80 16	1853. 95	+ 0. 92	+1. 82	+ 2. 74	County Surveyors	Ann. Rep. Sec. Int. Aff., 1876.
Doylestown	40 18	75 10	1876. 5	+ 5. 63	+0. 74	+ 6. 37	....do	Ann. Rep. Sec. Int. Aff., 1877.
Boundary at Lake Erie	42 16	79 46	1869. 71	+ 2. 58	+0. 94	+ 3. 52	Africa	MS.
Gettysburg	39 49	77 15	1866. 6	+ 3. 50	+1. 11	+ 4. 61	County Surveyors	Ann. Rep. Sec. Int. Aff., 1876.
Bedford	40 01	78 30	1877. 61	+ 3. 00	+0. 40	+ 3. 40	....do	Ann. Rep. Sec. Int. Aff., 1877.
Hopewell	40 07	78 17	1876. 62	+ 3. 18	+0. 46	+ 3. 64	... do	Ann. Rep. Sec. Int. Aff., 1876.
Towanda	41 47	76 30	1855. 5	+ 4. 33	+2. 10	+ 6. 43	... do	do.
Butler	40 54	79 50	1878. 6	+ 2. 25	+0. 37	+ 2. 62	....do	Ann. Rep. Sec. Int. Aff., 1878.
Johnstown	40 20	78 53	1875. 68	+ 2. 33	+0. 51	+ 2. 84	....do	Ann. Rep. Sec. Int. Aff., 1876.
Bellefonte	40 54	77 48	1855. 5	+ 2. 50	+1. 99	+ 4. 49	....do	do.
Morrisdale	41 02	78 08	1870. 81	+ 2. 70	+0. 77	+ 3. 47	....do	do.
Carlisle	40 12	77 11	1878. 3	+ 4. 00	+0. 35	+ 4. 35	....do	Ann. Rep. Sec. Int. Aff., 1878.
Ridgway	41 26	78 43	1855. 5	+ 1. 50	+2. 05	+ 3. 55	....do	Ann. Rep. Sec. Int. Aff., 1876.
Uniontown	39 54	79 43	1878. 74	+ 2. 70	+0. 36	+ 3. 06	....do	Ann. Rep. Sec. Int. Aff., 1878.
Chambersburg	39 56	77 40	1878. 3	+ 3. 40	+0. 36	+ 3. 76	....do	do.
Waynesburg	39 54	80 12	1877. 8	+ 2. 17	+0. 41	+ 2. 58	....do	Ann. Rep. Sec. Int. Aff., 1877.
Indiana	40 37	79 10	1857. 61	+ 1. 20	+1. 51	+ 2. 71	....do	Ann. Rep. Sec. Int. Aff., 1876.
Brookville	41 10	79 07	1878. 3	+ 2. 67	+0. 42	+ 3. 09	....do	Ann. Rep. Sec. Int. Aff., 1878.
Lebanon	40 20	76 26	1876. 3	+ 4. 87	+0. 46	+ 5. 33	....do	Ann. Rep. Sec. Int. Aff., 1876.
Lewistown	40 36	77 35	1876. 8	+ 3. 60	+0. 44	+ 4. 04	....do	do.
Somerset	40 01	79 04	1878. 3	+ 3. 07	+0. 34	+ 3. 41	....do	Ann. Rep. Sec. Int. Aff., 1878.
Montrose	41 50	75 57	1876. 8	+ 6. 25	+0. 57	+ 6. 82	....do	Ann. Rep. Sec. Int. Aff., 1876.
New York line, Tioga County	42 00	77 12	1876. 5	+ 5. 42	+0. 60	+ 6. 02	....do	do.
Lewisburg	40 58	77 12	1878. 8	+ 4. 87	+0. 34	+ 5. 21	....do	Ann. Rep. Sec. Int. Aff., 1878.
Honesdale	41 35	75 17	1876. 8	+ 6. 75	+0, 65	+ 7. 40	....do	Ann. Rep. Sec. Int. Aff., 1876.
Greensburg	40 19	79 32	1878. 8	+ 2. 80	+0. 36	+ 3. 16	....do	Ann. Rep. Sec. Int. Aff., 1878.
Washington	40 11	80 13	1876. 9	+ 2. 00	+0. 47	+ 2. 47	....do	Ann. Rep. Sec. Int. Aff., 1876.
York	39 58	76 44	1876. 9	+ 4. 90	+0. 43	+ 5. 33	....do	do.
Hollidaysburg	40 28	78 23	1877. 7	+ 4. 00	+0. 40	+ 4. 40	....do	Ann. Rep. Sec. Int. Aff., 1877
Clarion	41 14	79 24	1876. 5	+ 2. 33	+0. 53	+ 2. 86	....do	do.
Meadville	41 39	80 09	1877. 5	+ 2. 50	+0. 52	+ 3. 02	....do	do.
Allentown	40 36	75 28	1878. 2	+ 5. 08	+0. 60	+ 5. 68	....do	Ann. Rep. Sec. Int. Aff., 1878.
Sunbury	40 52	76 50	1878. 82	+ 4. 95	+0. 33	+ 5. 28	....do	do.
Warren	41 50	79 12	1878. 8	+ 3. 65	+0. 43	+ 4. 08	....do	do.
Tyrone	40 40	78 16	1879. 21	+ 3. 80	....	+ 3. 98	Waring	MS.
Altoona	40 31	78 25	1874. 54	+ 2. 78	+0. 57	+ 3. 35	Hilgard	Nat. Acad. Sc.
Sharpsville	41 17	80 27	1874. 59	+ 1. 00	+0. 59	+ 1. 59	....do	do.
Greenfield	40 06	79 52	1874. 62	+ 2. 04	+0. 59	+ 2. 63	....do	do.
Alleghany Observatory	40 28	80 01	1878. 68	+ 2. 36	....	+ 2. 72	Thorpe	Proc. Roy. Soc., 1880.
RHODE ISLAND, PART 1.								
McSparran	41 30	71 27	1844. 54	+ 8. 81	+2. 42	+11. 23		
Spencer	41 41	71 30	1844. 62	+ 9. 10	+2. 41	+11. 51		
Beaconpole	42 00	71 27	1844. 86	+ 9. 45	+2. 40	+11. 85		
Point Judith	41 22	71 29	1847. 68	+ 9. 00	+2. 22	+11. 22		
Watch Hill	41 19	71 51	1847. 72	+ 7. 56	+2. 22	+ 9. 78		
Providence	41 50	72 24	1855. 64	+ 9. 52	+1. 70	+11. 22		

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
RHODE ISLAND, PART 2.	° ′	° ′		°	°	°		
Newport	41 28	71 20	1832.5	+ 8.20	+3.17	+11.37	Wadsworth	Chart of Nar. Bay.
SOUTH CAROLINA, PART 1.								
Breach Inlet	32 46	79 49	1880.06	− 0.43	....	− 0.17		
Edisto Island, East Base	32 33	80 14	1850.26	− 2.89	+2.02	− 0.87		
Allston	33 22	79 17	1853.98	− 2.11	+1.80	− 0.31		
Port Royal	32 18	80 38	1859.09	− 3.07	+1.50	− 1.57		
Graham	32 13	80 46	1870.20	− 1.92	+0.82	− 1.10		
Beaufort	32 26	80 40	1875.37	− 1.97	+0.52	− 1.45		
SOUTH CAROLINA, PART 2.								
Robertsville	32 36	81 12	1843.5	− 3.42	+2.41	− 1.01	Feay	Agricultural Rep.
Columbia	34 00	81 02	1875.48	− 1.82	+0.52	− 1.30	Poole	Nat. Acad. Sc.
Florence	34 12	79 44	1875.48	− 1.20	+0.52	− 0.68	....do	do.
TENNESSEE, PART 1.								
Clifton	35 23	88 01	1865.18	− 5.80	+1.01	− 4.79		
Johnsonville	36 04	88 00	1865.19	− 5.83	+1.01	− 4.82		
Fort Henry	36 30	88 04	1865.19	− 6.40	+1.05	− 5.35		
Nashville	36 10	86 48	1877.93	− 5.25	+0.39	− 4.86		
Bristol	36 36	82 11	1881.52	− 0.64	+0.20	− 0.44		
Caryville	36 19	84 14	1881.53	− 1.20	+0.20	− 1.00		
Athens	35 27	84 37	1881.55	− 1.74	+0.20	− 1.54		
Chattanooga	35 00	85 18	1881.57	− 2.44	+0.20	− 2.24		
Tullahoma	35 22	86 13	1881.59	− 3.52	+0.20	− 3.32		
Murfreesboro'	35 53	86 25	1881.61	− 4.89	+0.19	− 4.70		
Columbia	35 37	87 04	1881.63	− 4.59	+0.19	− 4.40		
Pulaski	35 13	87 03	1881.65	− 5.02	+0.19	− 4.83		
Grand Junction	35 05	89 12	1881.69	− 5.98	+0.19	− 5.79		
Jackson	35 39	88 51	1881.71	− 5.83	+0.19	− 5.64		
Rutherford	36 09	89 01	1881.72	− 5.99	+0.19	− 5.80		
TENNESSEE, PART 2.								
Memphis	35 09	90 03	1877.55	− 6.78	+0.41	− 6.37	Powell	Ch. of Eng's Rep., 1878.
Knoxville	35 57	83 56	1875.46	− 2.25	+0.53	− 1.72	Hilgard	Nat. Acad. Sc.
Rogersville	36 25	83 03	1873.63	− 1.82	+0.62	− 1.20	....do	do.
Cleveland	35 10	85 00	1875.46	− 3.51	+0.53	− 2.98	....do	do.
Edgefield	36 15	86 46	1871.92	− 5.03	+0.69	− 4.34	....do	do.
TEXAS, PART 1.								
Dollar Point	29 26	94 53	1878.41	− 8.29	+0.29	− 8.00		
Galveston Island, East Base	29 13	94 56	1853.21	− 9.08	+1.25	− 7.83		
Jupiter	28 55	95 21	1853.36	− 9.14	+1.25	− 7.89		
Rio Grande, mouth	25 57	97 08	1853.85	− 9.02	+1.20	− 7.82		
Lavaca	28 38	96 37	1868.31	− 9.09	+0.60	− 8.49		
Austin	30 16	97 44	1878.47	− 8.96	+0.23	− 8.73		
San Antonio	29 25	98 29	1878.44	− 9.37	....	− 9.14		
Hempstead	30 08	96 10	1878.48	− 8.61	+0.27	− 8.34		
Groesbeck	31 33	96 30	1878.49	− 9.25	+0.27	− 8.98		
Fort Worth	32 45	97 20	1878.51	− 9.66	+0.25	− 9.41		
Sherman	33 36	96 36	1878.52	− 9.33	+0.26	− 9.07		
TEXAS, PART 2.								
Mouth of Sabine River, Everett's house.	29 44	93 51	1840.1	− 8.67	+1.55	− 7.12	Graham	Trans. Am. Phil. Soc., 1846.
Frontera	31 49	106 33	1859.06	−12.42	+0.00	−12.42	Clark	Rep. Com. Gen. Land Off., 47th Cong.
Ringgold Barracks	26 23	98 43	1853.5	− 9.25	+1.20	− 8.05	Emory	Am. Acad. Sc., 1856.
Fort McIntosh	27 35	99 45	1852.5	−10.60	+1.00	− 9.60	...do	do.
Eagle Pass	28 42	100 30	1852.5	−10.02	+0.95	− 9.07	....do	do.
Mouth of Cañon	31 02	105 37	1852.5	−12.02	0.00	−12.02	....do	do.
Burnet	30 44	98 06	1873.88	− 9.77	+0.37	− 9.40	Glenn	MS.
San Sabla	31 11	98 38	1874.00	−10.98	+0.37	−10.61	....do	MS.
Matagorda	28 41	95 58	1877.5	− 8.42	+0.31	− 8.11	Bishop	MS.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
Texas, Part 2—Continued.	° ′	° ′		°	°	°		
Brazos	30 42	96 20	1823.5	—10.62	+1.36	— 9.26	Austin Land Off. record.	MS.
Travis	30 16	97 44	1835.5	—10.00	+1.25	— 8.75	....do	MS.
Cherokee	31 45	95 00	1835.5	— 9.33	+1.55	— 7.78	... do	MS.
Longview	32 29	94 34	1872.29	— 8.63	+0.57	— 8.06	Hilgard	Nat. Acad. Sc.
Fork of Brazos River	33 00	99 17	1854.5	—11.20	+0.90	—10.30	U. S. officers	Phil. Trans. Roy. Soc., 1874.
Trinity Waters	33 34	98 15	1854.5	—10.45	+0.90	— 9.55	Pope	Pacific R. R. Explorations.
West Fork of Trinity River	33 29	98 52	1854.5	—10.28	+0.90	— 9.38	....do	do.
Elm Fork of Trinity River	33 42	97 23	1854.5	—10.60	+0.90	— 9.70	....do	Stone's Mag. Var.
Fort Bliss	31 46	106 29	1878.5	—12.42	+0.05	—12.37		Ch. of Eng's Rep., 1879.
Pass Cavallo	28 21	96 24	1879.6	— 8.33	+0.19	— 8.14	U. S. Eng's	Ch. of Eng's Rep., 1880.
Utah, Part 1.								
Salt Lake City	40 46	111 54	1881.36	—16.47	....	—16.56		
Castle Rock	41 08	111 10	1878.80	—16.95	+0.15	—16.80		
Ogden	41 14	112 00	1878.80	—17.27	+0.13	—17.14		
Kelton	41 45	113 08	1881.34	—17.76	+0.08	—17.68		
Corinne	41 33	112 06	1881.35	—17.52	+0.09	—17.43		
Utah, Part 2.								
Fillmore	38 57	112 17	1872.5	—16.25	+0.05	—16.20	Hoxie, Wheeler, Austin.	Ch. of Eng's Rep., 1876.
Kanab	37 02	112 32	1872.5	—14.38	0.00	—14.38	Marshall, Austin	do.
Antelope Springs	37 46	113 26	1872.5	—16.33	0.00	—16.33	Marshall	do.
Azay s Rauch	37 34	112 32	1872.5	—16.85	+0.05	—16.80	Hoxie	do.
Black Rock Spring	38 43	112 57	1872.5	—16.03	+0.05	—15.98	.. do	do.
Old Camp Floyd or Fairfield	40 16	112 05	1872.5	—16.99	+0.10	—16.89	....do	do.
Camp on Virgin River	37 08	113 26	1872.5	—15.48	0.00	—15.48	....do	do.
Cedar Springs	39 08	113 00	1872.5	—17.15	+0.05	—17.10	Marie	do.
Circleville	38 10	112 24	1872.5	—21.50	+0.05	—21.45	... do	do.
Cottonwood Creek, North	39 14	111 03	1873.5	—16.83	+0.12	—16.71	Hoxie	do.
Cottonwood Creek, South	39 05	111 07	1873.5	—16.27	+0.12	—16.15	....do	do.
Deseret City	39 14	112 44	1872.5	—16.23	+0.08	—16.15	....do	do.
Desert Spring	37 49	113 57	1872.5	—16.33	0.00	—16.33	Marshall	do.
Dirty Devil Cañon	38 17	111 00	1873.5	—16.30	+0.12	—16.18	Hoxie	do.
Dirty Devil River	38 16	111 11	1873.5	—16.33	+0.12	—16.21	....do	do.
Eureka City	39 58	112 07	1872.5	—17.15	+0.12	—17.03	Marshall	do.
Faust's Station	40 12	112 27	1872.5	—16.86	+0.12	—16.74	Hoxie	do.
Fish Spring	39 52	113 21	1872.5	—17.08	+0.08	—17.00	....do	do.
Grass Valley	38 34	111 50	1872.5	—17.75	+0.10	—17.65	Marshall	do.
do	38 20	111 54	1872.5	—17.75	+0.10	—17.65	....do	do.
Gunnison's Trail	38 48	111 30	1873.5	—16.00	+0.10	—15.90	Hoxie	do.
Hawawat Spring	38 30	113 30	1869.5	—16.66	0.00	—16.66	Wheeler, Lockwood.	do.
Hay Spring	38 19	113 00	1872.5	—16.26	+0.05	—16.21	Hoxie	do.
Iron City	37 33	113 27	1872.5	—18.50	0.00	—18.50	Marshall	do.
Joe's Valley	39 25	111 12	1873.5	—17.00	+0.14	—16.86	Hoxie	do.
Mammoth Mill	38 05	113 46	1873.5	—15.87	0.00	—15.87	... do	do.
Meadow Creek	38 51	112 26	1872.5	—16.18	+0.06	—16.12	....do	do.
Mill Spring Station	38 17	113 30	1872.5	—17.33	0.00	—17.33	....do	do.
Minersville	38 13	112 56	1872.5	—16.50	+0.03	—16.47	Marshall	do.
Mount Pleasant	39 32	111 29	1873.5	—17.17	+0.14	—17.03	Hoxie	do.
Muddy Creek	38 59	111 09	1873.5	—16.00	+0.14	—15.86	....do	do.
Paragoonah	37 55	112 48	1872.5	—19.50	+0.02	—19.48	Marshall	do.
Paria	37 11	111 53	1872.5	—14.50	+0.05	—14.45	... do	do.
Paria River	37 14	111 56	1872.5	—14.22	+0.05	—14.17	Hoxie	do.
Pine Valley, near	37 24	113 31	1872.5	—16.00	0.00	—16.00	Marshall	do.
Rabbit Valley	38 19	111 25	1873.5	—16.33	+0.10	—16.23	Hoxie	do.
San Francisco Spring	38 27	113 17	1872.5	—16.97	+0.02	—16.95	.. do	do.
Santaquin	39 59	111 48	1872.5	—17.43	+0.14	—17.29	Marshall	do.
Sevier Lake, camp near	38 50	113 15	1872.5	—17.47	+0.03	—17.44	Hoxie	do.
Sevier Pass	39 33	112 17	1872.5	—17.00	+0.10	—16.90	Marshall	do.
Virgin River	37 08	113 15	1872.5	—15.48	0.00	—15.48	Hoxie	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
UTAH, PART 2—Continued.	° ′	° ′		°	°	°		
Water Pocket, near Escalante River.	37 28	111 02	1873.5	−15.64	+0.10	−15.54	Hoxie	Ch. of Eng's Rep., 1876.
Welcome Creek	37 34	111 27	1873.5	−15.12	+0.08	−15.04	....do	do.
Bear River	42 12	111 08	1877.5	−17.99	+0.15	−17.84	Tillman	Ch. of Eng's Rep., 1878.
Logan River, East Fork	41 56	111 33	1877.5	−17.55	+0.15	−17.40	....do	do.
Ten Miles Southeast of Lake Town.	41 45	111 10	1877.5	−17.80	+0.15	−17.65	..do	do.
Meadowville, near	41 51	111 22	1877.5	−18.02	+0.15	−17.87	..do	do.
Schneider's Creek	40 56	111 42	1858.9	−18.92*	−0.36	−19.28	Simpson	Stone's Mag. Var., 1878.
Simpson's Spring	40 02	112 47	1859.4	−15.70*	−0.42	−16.12	....do	do.
Sulphur	39 41	113 46	1859.5	−14.93*	−0.50	−15.43	....do	do.
Fort Cameron	38 17	111 44	1873.5	−16.40	+0.08	−16.32		Ch. of Eng's Rep., 1879
VERMONT, PART 1.								
Burlington	44 28	73 12	1873.79	+11.32	....	+12.41		
Rutland	43 36	72 56	1879.79	+11.15	....	+11.84		
VERMONT, PART 2.								
Essex Junction	44 31	73 06	1849.65	+ 9.40	+2.77	+12.17	Clark	MS.
Swanton Falls	44 56	73 09	1850.29	+11.47	+2.95	+14.42	..do	MS.
West Hartford	43 41	72 17	1860.21	+11.15	+2.41	+13.56	....do	MS.
Barton	44 44	72 03	1837.5	+10.85	+3.66	+14.51	Twining	Sill. Jour., 1838.
Saint Johnsbury	44 26	71 55	1837.5	+ 9.27	+3.66	+12.93	....do	do.
Montpelier	44 17	72 36	1829.5	+12.42	+4.30	+16.72	Exec. documents	do.
Ryegate	44 10	72 10	1801.5	+ 7.00	+5.35	+12.35	Whitlaw	do.
Pawnal	42 46	72 59	1786.5	+ 5.87	+4.60	+10.47	Williams	do.
Bellow's Falls	43 09	72 28	1876.58	+11.11	+0.79	+11.90	Hilgard	Nat. Acad. Sc.
White River Junction	43 41	72 16	1876.59	+11.09	+0.79	+11.88	....do	do.
Wells River	44 09	72 05	1876.60	+11.91	+0.82	+12.73	....do	do.
Derby	45 00	72 12	1876.61	+13.30	+0.84	+14.14	....do	do.
VIRGINIA, PART 1.								
Petersburg	37 14	77 24	1871.78	+ 1.48	+0.83	+ 2.31		
Snead	37 58	75 26	1856.67	+ 2.31	+1.73	+ 4.04		
Joynes	37 42	75 37	1856.68	+ 2.06	+1.73	+ 3.79		
Scott	37 20	75 54	1856.68	+ 1.62	+1.75	+ 3.37		
Cape Charles	37 07	75 58	1856.68	+ 1.59	+1.75	+ 3.34		
Old Point Comfort	37 00	76 18	1856.69	+ 1.24	+1.75	+ 2.99		
Cape Henry light	36 56	76 00	1874.90	+ 2.66	....	+ 3.25		
Fredericksburg	38 18	77 27	1856.71	+ 1.04	+1.71	+ 2.75		
Peach Grove	38 55	77 14	1869.84	+ 2.91	+0.89	+ 3.80		
Wolf Trap	37 24	76 15	1871.36	+ 2.82	+0.86	+ 3.68		
Tangier	37 48	75 59	1871.47	+ 3.05	+0.82	+ 3.87		
Clark Mountain	38 19	78 00	1871.64	+ 1.78	+0.78	+ 2.56		
Bull Run	38 53	77 42	1871.79	+ 4.36	+0.77	+ 5.13		
North end Knott Island	36 34	75 55	1873.30	+ 2.91	+0.73	+ 3.64		
Williamsburg	37 16	76 43	1874.93	+ 2.20	+0.63	+ 2.83		
Greenwood	38 02	78 47	1880.43	+ 2.31	+0.25	+ 2.56		
Covington	37 48	79 58	1881.46	+ 1.05	+0.20	+ 1.25		
Wytheville	36 55	81 05	1881.48	− 0.02	+0.20	+ 0.18		
Marion	36 48	81 31	1881.50	+ 0.03	+0.20	+ 0.23		
VIRGINIA, PART 2.								
Charlottesville	38 01	78 31	1873.54	+ 1.28	+0.67	+ 1.95	Hilgard	Nat. Acad. Sc.
Richmond	37 32	77 26	1874.25	+ 2.26	+0.64	+ 2.90	Popp	Ch. of Eng's Rep., 1875.
Mobjack Bay	37 18	76 20	1824.0	+ 0.62	+3.01	+ 3.63	Boye	Boye's Map of Va., 1859.
North Carolina line, Greensville	36 36	80 50	1824.0	− 0.92	+2.82	+ 1.90	....do	do.
Staunton	38 09	79 04	1873.66	+ 0.76	+0.66	+ 1.42	Hilgard	Nat. Acad. Sc.
Peach Bottom, North Carolina line.	36 36	81 00	1824.0	− 3.83	+2.82	− 1.01	Boye	Boye's Map of Va., 1859.
Gosport navy-yard	36 49	76 17	1865.83	+ 2.63	+1.20	+ 3.83	Harkness	Smith'n Cont's to Kw., 239.
Strasburg	38 58	78 22	1873.52	+ 2.27	+0.67	+ 2.94	Hilgard	Nat. Acad. Sc.
Culpeper	38 28	78 00	1873.53	+ 2.35	+0.67	+ 3.02	....do	do.

*An index correction of +1° was applied to Simpson's observations.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
VIRGINIA, PART 2—Continued.	° ′	° ′		°	°	°		
Lynchburg	37 25	79 09	1873.55	+ 0.56	+0.67	+ 1.23	Hilgard	Nat. Acad. Sc.
Burkesville	37 13	78 12	1873.56	+ 2.00	+0.69	+ 2.69	....do	do.
Danville	36 37	79 20	1873.57	+ 1.27	+0.71	+ 1.98	....do	do.
Mount Airy	36 52	79 06	1873.64	— 0.92	+0.71	— 0.21	....do	do.
Christiansburg	37 11	80 18	1873.65	— 0.58	+0.64	+ 0.06	....do	do.
Natural Bridge	37 35	79 22	1873.65	+ 0.08	+0.66	+ 0.74	....do	do.
Harrisonburg	38 25	78 52	1873.67	+ 1.47	+0.66	+ 2.13	....do	do.
Powhatan County, Scottsville	37 30	77 54	1879.5	+ 2.50	+0.32	+ 2.82	County surveyor	MS.
Norfolk	36 51	76 17	1880.08	+ 2.95	+0.31	+ 3.26	Bernard	MS.
Emory and Henry College	36 40	81 46	1881.2	— 1.00	+0.21	— 0.79	Davis	MS.
WASHINGTON TERRITORY, PART 1.								
Cape Disappointment beach	46 17	124 03	1881.79	—21.60	....	—21.89		
Nee-ah Bay, astronomical station	48 22	124 38	1881.78	—22.74	....	—22.75		
Seattle	47 36	122 20	1881.86	—22.04	+0.02	—22.02		
Ainsworth	46 14	119 03	1881.64	—21.41	—0.03	—21.44		
Sixty-mile Well	46 49	118 50	1881.65	—22.78	—0.02	—22.80		
Sprague	47 19	118 10	1881.65	—22.92	0.00	—22.92		
Spokane Falls	47 43	117 23	1881.67	—21.66	+0.02	—21.64		
Pomeroy	46 31	117 40	1881.72	—21.56	+0.01	—21.55		
Walla-Walla C. H	46 04	118 20	1881.73	—22.07	—0.01	—22.08		
Wallula	46 07	118 55	1881.75	—19.93	—0.02	—19.95		
Lower Cascades	45 39	122 00	1881.80	—19.49	—0.10	—19.59		
Vancouver, near old fort	45 38	122 39	1881.82	—20.89	—0.11	—21.00		
Olympia	47 02	122 54	1881.84	—21.58	—0.03	—21.61		
Port Townshend	48 07	122 45	1881.88	—21.45	....	—21.38		
WASHINGTON TERRITORY, PART 2.								
Off Gray's Harbor	47 00	123 53	1792.96	—18.00	....	....	Vancouver	Hansteen's Erdmag.
Port Discovery, mill	48 01	122 51	1862.50	—22.00	—0.42	—22.42	Garfielde	MS.
Point Roberts	48 59	123 01	1858.20	—22.55	—0.47	—23.02	....do	MS.
North Point, Nee-ah Island	48 25	124 36	1841.50	—22.50	—1.28	—23.78	Chart	U. S. Expl. Exp'n.
Nisqually	47 07	122 38	1859.50	—21.38	—0.65	—22.03	Haig	Phil. Trans. Roy. Soc., 1864
Colville, barracks	48 40	118 05	1861.50	—21.67	—0.40	—22.07	....do	do.
Chunikane River	48 00	117 45	1861.50	—21.47	—0.40	—21.87	....do	do.
Old Fort Walla-Walla	46 04	118 48	1853.50	—19.67	—0.55	—20.22	Stevens	C. S. Rep., 1856.
Colville, depot	48 33	117 52	1860.50	—22.52	—0.40	—22.92	Harris	N. W. Bound. Com. Chart.
Near Spokane Ferry	47 48	117 58	1860.50	—22.12	—0.40	—22.52	....do	do.
Peon's prairie	47 43	117 14	1860.50	—21.88	—0.40	—22.28	....do	do.
Station in	49 00	118 44	1860.50	—22.12	—0.40	—22.52	....do	do.
Lugenbeel's Creek	47 09	118 07	1860.5	—20.92	—0.40	—21.32	....do	do.
Cow Creek	46 53	118 10	1860.5	—21.01	—0.40	—21.41	....do	do.
Tucanon River	46 32	118 00	1860.5	—20.92	—0.40	—21.32	....do	do.
Dry Creek	46 10	118 18	1860.5	—20.22	—0.40	—20.62	....do	do.
Station in	49 00	119 35	1860.5	—23.57	—0.45	—24.02	....do	do.
Near Wallula	46 02	119 00	1860.5	—19.77	—0.40	—20.17	....do	do.
Station in	49 00	121 23	1860.5	—22.15	—0.50	—22.65	....do	do.
do	48 59	121 42	1860.5	—22.78	—0.50	—23.28	....do	do.
do	48 59	121 57	1860.5	—22.65	—0.50	—23.15	....do	do.
Admiralty Head, Whitbey Island	48 09	122 41	1857.5	—21.90	—0.55	—22.45	Garfielde	MS.
Guide meridian, Bellingham Bay	48 33	122 27	1859.5	—22.15	—0.50	—22.65	....do	MS.
Columbia River, Township 6	46 00	118 58	1860.5	—18.83	—0.40	—19.23	....do	MS.
Columbia, guide meridian, Snake River.	46 15	118 58	1860.5	—20.00	—0.40	—20.40	....do	MS.
do	47 55	118 58	1860.5	—22.00	—0.40	—22.40	....do	MS.
Small Island, Columbia River	45 52	119 39	1860.5	—18.00	—0.40	—18.40	....do	MS.
Gray's Bay, Columbia River	46 18	123 42	1858.5	—21.62	—1.20	—22.82	....do	MS.
Near Mount Adams	46 12	121 03	1860.5	—20.50	—0.50	—21.00	....do	MS.
Station in	46 18	117 51	1860.5	—18.75	—0.40	—19.15	....do	MS.
Crossing Pataha Creek	46 23	117 34	1863.5	—21.25	—0.35	—21.60	....do	MS.
Crossing Columbia River in	46 34	119 18	1863.5	—21.50	—0.35	—21.85	....do	MS.
Mouth of Strong's River	46 15	123 23	1855.5	—20.00	—1.25	—21.25	....do	MS.
Crossing Snake River	46 34	118 04	1860.5	—19.00	—0.40	—19.40	....do	MS.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
WASHINGTON TERRITORY, PART 2—Continued.	° ′	° ′		°	°	°		
East side of Shoalwater Bay	46 33	123 54	1856.5	−20.50	−1.10	−21.60	Garfielde	MS.
Fourth standard parallel and Gray's Harbor.	46 54	124 01	1855.5	−22.00	−1.00	−23.00	....do	MS.
Station in	47 16	122 05	1855.5	−21.00	−0.50	−21.50	....do	MS.
Intersection fifth standard parallel and ocean.	47 15	124 12	1859.5	−21.75	−0.65	−22.40	....do	MS.
Intersection fifth standard parallel and Hood's Canal.	47 15	123 08	1856.5	−21.58	−0.65	−22.23	....do	MS.
Station in	47 36	121 42	1865.5	−22.33	−0.40	−22.73	....do	MS.
Point Elliott	47 57	122 18	1855.5	−21.50	−0.55	−22.05	....do	MS.
Foulweather Bluff	47 56	122 36	1859.5	−20.50	−0.45	−20.95	....do	MS.
Dungeness Light	48 11	123 06	1858.5	−21.50	−0.45	−21.95	....do	MS.
Leadbetter Point	46 36	124 [illegible]3	1859.5	−21.08	−0.80	−21.88	....do	MS.
Shoalwater Bay Light	46 43	124 04	1858.5	−21.08	−0.75	−21.83	....do	MS.
Chehalis Point	46 55	124 07	1858.5	−21.50	−0.75	−22.25	....do	MS.
North head of Gray's Harbor	47 03	124 05	1858.5	−2[illegible].50	−1.20	−22.70	....do	MS.
Clattam Bay	48 15	124 16	1864.5	−22.50	−0.37	−22.87	....do	MS.
Head of Hood's Canal	47 28	122 50	1856.5	−21.50	−0.40	−21.90	....do	MS.
Seabeck, Hood's Canal	47 39	122 49	1859.5	−22.00	−0.35	−22.35	....do	MS.
Port Madison, mill	47 43	122 33	1856.5	−20.50	−0.40	−20.90	....do	MS.
Port Gamble, mill	47 51	122 34	1859.5	−20.83	−0.35	−21.18	....do	MS.
Deception Pass, north of Whitbey Island.	48 24	122 40	1858.5	−21.75	−0.40	−22.15	....do	MS.
Fort Bellingham	48 47	122 32	1859.5	−22.50	−0.40	−22.90	....do	MS.
Monticello	46 07	122 55	1857.5	−19.83	−0.40	−20.23	....do	MS.
Mouth of Skookum Chuck	47 45	122 40	1856.5	−21.00	−0.40	−21.40	....do	MS.
Steilacoom	47 10	122 35	1856.5	−21.50	−0.40	−21.90	....do	MS.
Fort Simcoe	46 30	120 40	1865.5	−21.50	−0.30	−21.80	....do	MS.
Restoration Point	47 30	122 14	1792.40	−19.60	....	....	Vancouver	Voyage of disc., 1798.
Birch Bay	48 54	122 27	1792.50	−19.50	....	....	....do	do.
Chequees	45 56	121 23	1854.5	−16.08	−0.50	−16.58	Pope	Stone's Mag. Var., 1878.
Wenatshapaw	47 29	120 38	1854.5	−18.83	−0.50	−19.33	....do	do.
WEST VIRGINIA, PART 1.								
Clarksburg	39 17	80 20	1880.94	+ 1.76	+0.25	+ 2.01		
Grafton	39 21	80 02	1864.03	+ 1.86	+1.46	+ 3.32		
Cameron	39 50	80 34	1864.04	− 0.40	+1.46	+ 1.06		
Wheeling	40 03	80 44	1881.40	+ 0.02	+0.20	+ 0.22		
Parkersburg	39 16	81 34	1881.41	+ 0.12	+0.25	+ 0.37		
Point Pleasant	38 50	82 09	1864.08	− 1.58	+1.46	− 0.12		
Charleston	38 21	81 38	1881.43	+ 1.05	+0.25	+ 1.30		
Alderson	37 45	80 40	1881.45	+ 0.92	+0.22	+ 1.14		
WEST VIRGINIA, PART 2.								
North Branch of Potomac	39 30	79 00	1824.0	− 1.58	+3.30	+ 1.72	Boye	Boye's Map of Va., 1859.
Bull Town	38 48	80 31	1824.0	− 2.17	+3.23	+ 1.06	....do	do.
Cumberland Gap	39 40	78 40	1824.0	− 4.58(?)	+3.30	− 1.28	....do	do.
Martinsburg	39 27	77 57	1873.52	+ 2.86	+0.73	+ 3.59	Hilgard	Nat. Acad. Sc.
Pruntytown	39 19	80 06	1882.15	+ 2.25	+0.19	+ 2.44	Smith	MS.
WISCONSIN, PART 1.								
Madison, University Farm	43 04	89 25	1881.96	− 6.35	+0.20	− 6.15		
La Crosse	43 49	91 15	1877.73	− 8.63	+0.47	− 8.16		
Superior City	46 40	92 04	1880.64	− 9.76	+0.40	− 9.36		
WISCONSIN, PART 2.								
Milwaukee	43 03	87 55	1878.4	− 6.72	+0.60	− 6.12	Houston	Ch. of Eng's Rep., 1878.
Monroe	42 37	89 41	1859.61	− 8.41	+1.65	− 6.76	Dodge	MS.
Sheboygan	43 44	87 43	1865.5	− 5.25	+1.72	− 3.53	....	Sur. of N. & N. W. Lakes, MS.
Grassy Point, Fort Howard	44 33	87 55	1865.5	− 5.52	+1.72	− 3.80	Dodge	do.
Racine	42 44	87 47	1865.5	− 5.25	+1.35	− 3.90	....do	do.
Fort Crawford	43 03	90 52	1823.5	− 8.82	+2.16	− 6.66	Long's Exp'n	Sill. Jour., 1838.
South point Madeline Island	46 45	90 55	1824.5	− 9.80	....	....	Bayfield	Phil. Trans. Roy. Soc., 1872.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
WISCONSIN, PART 2—Continued.	° ′	° ′		°	°	°		
Trout Brook	42 59	90 45	1839.82	— 9.00	+2.19	— 6.81	Surveyors	Locke's Min. Lands., Ex. Doc., 1839–'40.
Parish	42 58	90 10	1839.82	— 8.92	+2.19	— 6.73	....do	do.
Blue Mound	43 01	89 38	1839.83	— 8.63	+2.19	— 6.44	.. do	do.
Campbell	43 01	89 26	1839.84	— 8.64	+2.19	— 6.45	Locke, Surveyors	do.
Mineral Point	42 51	89 58	1839.84	— 8.67	+2.19	— 6.48	Surveyors	do.
Long Tail Point Light	44 36	87 54	1845.5	— 6.42	+2.50	— 3.92	Chart	U. S. Lake Sur.
WYOMING TERRITORY, PART 1.								
Sherman	41 08	105 24	1872.58	—15.88	+0.31	—15.57		
Cheyenne	41 08	104 49	1878.70	—15.34	+0.15	—15.19		
Laramie	41 19	105 36	1878.73	—15.12	+0.15	—14.97		
Rock Creek	41 50	106 05	1878.73	—15.76	+0.15	—15.61		
Fort F. Steele	41 47	106 57	1878.74	—16.17	+0.15	—16.02		
Creston	41 48	107 57	1878.75	—16.06	+0.14	—15.92		
Point of Rocks	41 43	108 58	1878.76	—16.30	+0.14	—16.16		
Green River	41 32	109 29	1878.77	—16.77	+0.13	—16.64		
Carter	41 36	110 26	1878.78	—17.10	+0.13	—16.97		
Northeast corner Wyoming Territory.	45 00	104 03	1882.45	—15.65	+0.06	—15.59		
Little Missouri River Station	45 00	104 25	1882.49	—16.19	+0.06	—16.13		
Mile Posts 283–284	45 00	105 20	1882.51	—16.92	+0.06	—16.86		
Mile Post 185	45 00	107 21	1882.54	—17.96	+0.05	—17.91		
Mile Post 42	45 00	110 12	1882.63	—19.52	+0.05	—19.47		
WYOMING TERRITORY, PART 2.								
Powder River	43 38	106 33	1859.5	—16.53	+0.30	—16.23		Missouri and Yellowstone Exp'n, MS.
Deer Creek	43 19	105 52	1859.5	—16.38	+0.35	—16.03		do.
Bad Water River	43 08	107 53	1860.5	—16.00	+0.20	—15.80		do.
Popo Agie River	43 00	108 28	1860.5	—15.20	+0.15	—15.05		do.
Wind River	43 32	110 00	1860.5	—19.50	0.00	—19.50		do.
Pass no Pass	43 33	110 23	1860.5	—20.75	0.00	—20.75		do.
Camp Aspen Hut	42 30	108 58	1858.47	—16.70	+0.15	—16.55	Wagner	MS.
Mouth of Piney Cañon	42 32	109 58	1858.56	—17.88	0.00	—17.88	....do	MS.
Teton Cañon	43 46	111 00	1872.56	—17.92	+0.15	—17.77	Hayden	6th Ann. Rep. Geol. Sur. Terr's.
Bechler's Fork	44 11	110 58	1872.59	—18.25	+0.15	—18.10	....do	do.
Lower Geyser Basin	44 34	110 30	1872.62	—18.48	+0.18	—18.30	.. do	do.
Upper Geyser Basin	44 28	110 30	1872.63	—18.48	+0.18	—18.30	....do	do.
Shoshone Lake	44 21	110 40	1872.68	—18.25	+0.17	—18.08	....do	do.
Lewis Fork	44 14	110 33	1872.70	—18.22	+0.18	—18.04	... do	do.
Mouth of Lewis Fork	44 08	110 40	1872.71	—18.13	+0.17	—17.96	....do	do.
Beula Lake	44 09	110 44	1872.71	—18.92	+0.17	—18.75	....do	do.
Camp 42, foot of Jackson Lake	43 52	110 41	1872.73	—17.93	+0.17	—17.76	....do	do.
East Foot of Tetons	43 47	110 43	1872.74	—17.70	+0.17	—17.53	....do	do.
Camp 44	43 40	110 43	1872.74	—17.63	+0.17	—17.46	....do	do.
Snake River	43 32	110 49	1872.75	—17.67	+0.17	—17.50	....do	do.
Bear River	41 54	111 00	1877.5	—18.22	+0.15	—18.07	Tillman	Ch. of Eng.'s Rep., 1878.
Smoky Creek	42 47	111 04	1877.5	—18.42	+0.15	—18.27	....do	do.
Chugwater Creek	41 45	104 50	1877.53	—15.31	+0.18	—15.13	Stanton	do.
Chugsprings	41 59	104 51	1877.53	—15.44	+0.18	—15.26	....do	do.
Lance Creek	43 19	104 20	1877.59	—15.24	+0.18	—15.06	... do	do.
South Cheyenne River	43 33	104 09	1877.60	—15.67	+0.18	—15.49	... do	do.
Beaver Creek Valley	43 53	104 06	1877.60	—15.87	+0.18	—15.69	... do	do.
Redwater Creek	44 32	104 06	1877.63	—15.67	+0.18	—15.49	... do	do.
Gilliss Creek	44 27	104 36	1877.64	—16.19	+0.18	—16.01	....do	do.
Belle Fourche River	44 11	105 05	1877.64	—16.15	+0.17	—15.98	....do	do.
A swale	43 51	105 37	1877.64	—16.33	+0.17	—16.16	....do	do.
A small brook	43 39	105 52	1877.65	—16.72	+0.16	—16.56	....do	do.
Fort McKinney	43 47	106 15	1877.66	—17.01	+0.16	—16.85	....do	do.
Southeast base Laramie Peak	42 15	105 23	1877.72	—16.71	+0.17	—16.54	....do	do.
Fort Laramie	42 12	104 34	1877.73	—15.41	+0.18	—15.23	....do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
WYOMING TERRITORY, PART 2—Continued.	° ′	° ′		°	°	°		
La Bonté River	42 35	105 22	1858.8	—15.38*	+0.35	—15.03	Simpson	Stone's Mag. Var., 1878.
West of Deer Creek	42 53	105 57	1858.8	—15.47*	+0.35	—15.12	do	do.
Greasewood Creek	42 40	107 07	1858.8	—17.40*	+0.25	—17.15	do	do.
Sweetwater River	42 38	107 25	1858.8	—16.68*	+0.25	—16.43	do	do.
do	42 30	108 35	1858.8	—16.93*	+0.15	—16.78	do	do.
Little Sandy Creek	42 15	109 40	1858.8	—17.73*	+0.05	—17.68	do	do.
Fort Bridger	41 20	110 24	1858.9	—16.62*	—0.10	—16.72	do	do.
Tongue River	44 53	107 14	1859.5	—16.50	+0.25	—16.25	....	MS. by Raynolds.
Hot Springs, White Mountains	44 58	110 43	1872.57	—19.28	+0.17	—19.11	Hayden	Geol. Sur., 6th Ann. Rep.
Yellowstone Falls	44 44	110 34	1872.58	—19.00	+0.17	—18.83	do	do.
Lower Geyser Basin	44 34	110 55	1872.62	—18.48	+0.17	—18.31	do	do.
CANADA, EAST OF LONG. 90°, PART 1.								
Quebec	46 48	71 14	1879.72	+17.23	+0.17	+17.40		
Montreal	45 30	73 35	1879.73	+13.68	+0.42	+14.10		
Chamcook, N. B.	45 08	67 05	1859.79	+17.60	+1.33	+18.93		
Halifax, N. S	44 40	63 35	1879.69	+20.72	—0.22	+20.50		
Michipicoten	47 56	84 51	1880.62	+ 1.34	......	+ 2.29		
Foot of Long Portage	47 55	84 45	1880.62	+ 3.23	+0.96	+ 4.19		
Big Stony Portage	48 14	84 15	1880.57	+ 4.20	+0.97	+ 5.17		
Sandy Beach	48 18	84 01	1880.57	+ 1.32	+0.97	+ 2.29		
Fairy Point	48 21	83 44	1880.58	+ 3.37	+0.97	+ 4.34		
Missinaibi	48 29	83 28	1880.58	+ 2.35	+0.96	+ 3.31		
Twin Portage	49 12	83 24	1880.59	+ 4.97	+0.90	+ 5.87		
Kettle Portage	49 47	83 16	1880.60	+ 4.25	+0.87	+ 5.12		
Near Cedar Island	50 21	82 42	1880.63	+ 5.24	+0.82	+ 6.06		
Moose River, near Falling Brook	50 36	82 07	1880.61	– 7.95	+0.80	+ 8.75		
Moose Factory	51 15	80 40	1880.63	+15.46	+0.75	+16.21		
Gypsum Beds	50 50	81 15	1880.65	+ 9.88	+0.80	+10.68		
Long Gravel Bed	50 44	81 48	1880.65	+ 8.03	+0.80	+ 8.83		
Store House Portage	50 04	83 16	1880.66	+ 4.91	+0.85	+ 5.76		
Albany Rapids	49 22	83 30	1880.67	+ 4.18	+0.90	+ 5.08		
Moose River	49 08	83 22	1880.67	+ 4.34	+0.90	+ 5.24		
Saint Paul's Rapids	48 50	83 24	1880.68	+ 4.17	+0.93	+ 5.10		
Foot of Swampy Grounds Portage	48 42	83 24	1880.68	+ 0.21	+0.93	+ 1.14		
Sidney, Cape Breton	46 09	60 12	1881.81	+25.20	—0.18	+25.02		
Arichat, Isle Madame	45 30	61 01	1881.82	+23.43	—0.16	+23.27		
Yarmouth, N. S	43 50	66 07	1881.85	+17.82	+0.06	+17.88		
Weymouth, N. S	44 24	66 00	1881.86	+18.72	+0.06	+18.78		
Annapolis, N. S	44 44	65 31	1881.87	+19.45	+0.06	+19.51		
Windsor, N. S	45 00	64 08	1881.89	+20.70	0.00	+20.70		
CANADA, EAST OF LONG. 90°, PART 2.								
Terre Platte	48 40	87 45	1843.5	— 5.67	+6.20	+ 0.53	Lefroy	Trans. Roy. Soc., 1872.
Rondeau Light	42 16	81 54	1845.5	— 1.07	+2.17	+ 1.10	Chart	U. S. Lake Sur.
Long Point Light	42 33	80 06	1845.5	+ 0.92	+2.86	+ 3.78	do	do.
Toronto Magnetic Observatory	43 39	79 23	1880.80	+ 3.68	....	+ 3.88		
Cove Island, entrance to Georgian Bay.	45 19	81 42	1860.5	+ 3.80	+2.40	+ 6.20	....	Sur. of Lakes, MS.
Northeast Boundary, claimed before 1842.	48 00	67 47	1838.5	+19.20	+2.89	+22.07	Marine State Survey.	Sill. Jour., 1840.
Goderich	43 44	81 43	1860.5	+ 1.70	+2.25	+ 3.95	....	Sur. of Lakes, MS.
Drummond Island	45 56	83 42	1859.5	— 0.22	+1.55	+ 1.33	....	do.
Charlotte Town	46 14	63 27	1862.41	+23.32	....	+23.17	Orlebar	MS.
Miramichi, Vin Island	47 06	65 04	1857.4	+21.40	+0.40	+21.80	do	MS.
Black Rock, near Light	45 10	64 46	1856.5	+18.73	+0.75	+19.48	Shortland	MS.
Shelburn Light	43 37	65 16	1859.5	+17.78	+0.62	+18.40	do	MS.
Negro Harbor	43 33	65 25	1859.5	+17.33	+0.62	+17.95	do	MS.

*An index correction of +3° was applied to Simpson's observations.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
CANADA, EAST OF LONG. 90°, PART 2—Continued.	° ′	° ′		°	°	°		
New Brunswick, or Mispeck	45 12	66 00	1859.5	+18.27	+1.21	+19.48	Shortland	MS.
Tip Top	48 15	86 07	1871.65	— 0.05	+2.77	+ 2.72	Orlebar	MS.
Point Yeo	44 03	76 30	1818.5	+ 2.50	+5.50	+ 8.00	Owen	22d Ann. Rep. Regents, N. Y.
Two Miles above Ogdensburg	44 44	75 32	1818.5	+ 3.50	+6.25	+ 9.75	....do	do.
Chester Harbor	44 36	64 10	1775.5	+13.50	+6.50	+20.00	Des Barres	Atlantic Neptune.
Cape Sable	43 20	65 30	1828.5	+12.00	+2.50	+14.50	Cart. du Depot	Becquerel's Traité du Mag.
Richmond Junction	45 41	72 03	1876.63	+16.99	+0.44	+17.43	Hilgard	Nat. Acad. Sc.
Beçancour	46 22	71 33	1876.63	+15.72	+0.20	+15.92	... do	do.
Saint Thomas	46 59	70 23	1876.65	+17.84	+0.20	+18.04	... do	do.
Riviere au Loup en bas	47 51	69 25	1876.66	+20.65	+0.20	+20.85	....do	do.
Penetangushene	44 49	80 01	1848.5	+ 1.47	+3.48	+ 4.95	Typer	Phil. Trans. Roy. Soc., 1872.
Trembling Portage	48 31	90 00	1857.5	— 6.35			Palliser	do.
Halting Place	48 55	89 54	1857.5	— 9.08			... do	do.
do	48 45	89 53	1857.5	— 8.90			...do	do.
Grand Portage	47 58	89 49	1824.5	—11.00			Bayfield	do.
Bad Portage	48 29	89 40	1843.5	— 5.55			Lefroy	do.
Dog Lake	48 47	89 40	1843.5	— 6.43			...do	do.
Fort William	48 24	89 23	1844.5	— 6.35			.. do	do.
Little Trout River	47 09	88 54	1824.5	— 9.20			Bayfield	do.
Isle Royale	48 07	88 49	1824.5	— 9.65			....do	do.
Isle Saint Ignace	48 45	88 02	1824.5	— 8.25			... do	do.
Point on Shore	48 44	87 00	1824.5	— 7.70			...do	do.
Fort Pic	48 38	86 39	1844.5	— 5.52			Lefroy	do.
Peninsular Harbor	48 44	86 28	1824.5	— 6.33	+6.85	+ 0.52	Bayfield	do.
White River	48 33	86 27	1844.5	— 2.17	+6.14	+ 3.97	Lefroy	do.
Otter Head	48 05	86 10	1824.5	— 5.12	+6.85	+ 1.73	Bayfield	do.
Le Petit Mort	47 58	85 49	1843.5	— 4.98	+6.20	+ 1.22	Lefroy	do.
Near Chienne River	47 52	85 24	1843.5	— 2.37	+6.20	+ 3.83	....do	do.
Gargantua	47 35	85 11	1824.5	— 4.10	+5.35	+ 1.25	Bayfield	do.
Point au Crépe	46 58	84 58	1843.5	— 2.25	+3.50	+ 1.25	Lefroy	do.
Montreal Island	47 19	84 52	1824.5	— 3.47	+4.60	+ 1.13	Bayfield	do.
Point Iroquois	46 29	84 47	1824.5	— 3.37	+2.35	— 1.02	....do	do.
Head of Lake George	46 32	84 20	1825.5	— 3.32	+2.35	— 0.97	... do	do.
Saint Joseph's Island	46 04	84 09	1822.5	— 3.00	+2.32	— 0.68	....do	do.
Portlock Harbor	46 20	84 07	1822.5	— 2.85	+2.32	— 0.53	.. do	do.
Bear Encampment	46 20	83 56	1845.5	— 0.05	+2.08	+ 2.03	Lefroy	do.
Tessalon Point	46 16	83 31	1843.5	+ 0.52	+2.14	+ 2.66	....do	do.
Missesauga	46 08	83 10	1843.5	+ 0.92	+2.14	+ 3.06	....do	do.
Cranberry Bay	46 11	83 03	1845.5	+ 0.42	+2.08	+ 2.50	....do	do.
Fort La Cloche	46 07	82 25	1843.5	+ 1.97	+2.14	+ 4.11	....do	do.
Manitoulin Island	45 28	81 54	1821.5	— 1.22	+4.53	+ 3.31	Bayfield	do.
Cape Hurd	45 14	81 51	1821.5	— 0.35	+4.53	+ 4.18	....do	do.
Rattlesnake Harbor	45 32	81 49	1821.5	— 0.83	+4.53	+ 3.70	....do	do.
Point on Shore	45 57	81 38	1821.5	+ 0.52	+3.45	+ 3.97	... do	do.
Half Moon Island	45 27	81 35	1821.5	— 0.37	+3.45	+ 3.08	... do	do.
Lake Huron	45 57	81 32	1843.5	+ 0.63	+3.21	+ 3.84	Lefroy	do.
White Shingle Bank	45 37	81 31	1821.5	— 0.35	+3.45	+ 3.10	Bayfield	do.
Cabot's Head	45 15	81 26	1819.5	— 0.40	+3.75	+ 3.35	....do	do.
Chin Cape	45 07	81 25	1819.5	— 0.65	+3.75	+ 3.10	... do	do.
Islet off Grondine Point	45 54	81 15	1821.5	+ 0.53	+3.45	+ 3.98	....do	do.
Islet off Henner Inlet	45 51	80 53	1821.5	— 1.55	+3.60	+ 2.05	....do	do.
Islet off Franklin Inlet	45 33	80 38	1821.5	— 0.67	+3.75	+ 3.08	.. do	do.
Western Isles	45 05	80 25	1820.5	— 1.42	+3.90	+ 2.48	... do	do.
Portage du Grandvase	46 19	79 07	1843.5	+ 3.87	+3.24	+ 7.11	Lefroy	do.
Roche Capitaine	46 15	78 20	1843.5	+ 4.80	+3.50	+ 8.30	... do	do.
Fort Portage	45 36	76 53	1843.5	+ 5.18	+4.00	+ 9.18	....do	do.
Point Aylmer	45 29	75 48	1843.5	+ 6.97	+4.23	+11.20	....do	do.
Alfred Township	45 37	75 12	1843.5	+ 6.97	+4.33	+11.30	...do	do.
Point aux Chênes	45 37	74 55	1843.5	+ 7.47	+4.33	+11.80	....do	do.
Carillon	45 36	74 32	1843.5	+ 8.68	+4.33	+13.01	... do	do.
River La Graise	45 36	74 22	1843.5	+ 8.43	+4.33	+12.76	... do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
CANADA, EAST OF LONG. 90°, PART 2—Continued.	° ′	° ′		°	°	°		
Isle de Grace	46 06	73 07	1830.5	+10.45	+5.43	+15.88	Bayfield	Phil. Trans. Roy. Soc., 1872.
Stone Island	46 06	73 02	1830.5	+10.50	+5.43	+15.93	do	do.
Sorel	46 03	73 00	1842.5	+11.37	+4.12	+15.49	Lefroy	do.
Saint John's, near Montreal	45 19	73 00	1842.5	+11.37	+4.47	+15.84	do	do.
Isle Lake Saint Peter	46 14	72 44	1828.5	+11.25	+5.37	+16.62	do	do.
River Saint Maurice	46 21	72 43	1835.5	+11.53	+4.75	+16.28	Bayfield	do.
Three Rivers	46 19	72 36	1842.5	+11.97	+3.95	+15.92	Lefroy	do.
Drumondville	45 53	72 34	1842.5	+12.47	+3.95	+16.42	do	do.
Isle Bigot and River Champlain	46 26	72 24	1835.5	+12.69	+4.75	+17.44	Bayfield	do.
Grondine	46 34	72 24	1835.5	+12.45	+4.75	+17.20	do	do.
Stanstead	45 02	72 10	1845.5	+11.55	+3.26	+14.81	Bound. Sur	do.
Platon Point	46 40	71 54	1837.5	+12.87	+4.34	+17.21	Bayfield	do.
Prospect Hill and Connecticut River.	45 15	71 14	1845.5	+12.14	+2.63	+14.77	Bound. Sur	do.
Highland Boundary	45 18	71 05	1845.5	+13.33	+2.63	+15.96	do	do.
Arnold's River	45 20	70 55	1845.5	+13.50	+2.63	+16.13	do	do.
Dead River	45 26	70 48	1845.5	+13.17	+2.63	+15.80	do	do.
Highland Boundary	45 31	70 43	1845.5	+13.42	+2.63	+16.05	do	do.
do	45 37	70 37	1845.5	+13.62	+2.63	+16.25	do	do.
Crane Island	47 05	70 32	1831.5	+14.47	+4.50	+18.97	Bayfield	do.
Highland Boundary	45 42	70 28	1844.5	+13.83	+2.72	+16.55	Bound. Sur	do.
Isle aux Coudres	47 25	70 26	1831.5	+15.28	+4.50	+19.78	Bayfield	do.
Stone Pillar	47 12	70 22	1831.5	+14.82	+4.50	+19.32	do	do.
Tadousac	48 09	69 44	1829.5	+17.58	+4.00	+21.58	do	do.
Brandy Pot Island	47 53	69 42	1836.5	+17.42	+3.50	+20.92	do	do.
Riviere du Loup	47 51	69 35	1831.5	+17.60	+3.75	+21.35	do	do.
Razade Inlet	48 13	69 09	1829.5	+17.57	+3.75	+21.32	do	do.
Port Neuf	48 37	69 07	1831.5	+17.60	+3.60	+21.20	do	do.
Bic Island	48 25	68 49	1830.5	+17.48	+3.50	+20.98	do	do.
Bersimis Point	48 56	68 38	1831.5	+18.80	......	......	do	do.
Saint Nicholas Harbor	49 19	67 48	1830.5	+19.95	......	......	do	do.
Point de Monts	49 19	67 23	1830.5	+20.22	......	......	do	do.
Egg Island	49 38	67 11	1832.5	+21.58	......	......	do	do.
Cape Chatte	49 06	66 46	1830.5	+21.45	......	......	do	do.
Dalhousie Island	48 04	66 23	18[illegible].5	+20.25	......	......	do	do.
Carleton Point	48 05	66 08	1838.5	+20.38	......	......	do	do.
Mount Lewis River	49 15	65 45	1828.5	+22.00	......	......	do	do.
Passebiac	48 01	65 35	1838.5	+21.35	......	......	do	do.
Cape Ipperwash	43 13	82 00	1860.35	− 0.06	+2.25	+ 2.19	Smith	Rep. U. S. Lake Sur., 1882.
Caraquetta Island	47 50	64 53	1838.5	+21.50	......	......	Bayfield	Phil. Trans. Roy. Soc., 1872.
Richibucto River	46 43	64 49	1839.5	+19.83	+2.75	+22.58	do	do.
Point Maquereau	48 12	64 47	1837.5	+22.00	......	......	do	do.
Shipfrigau Harbor	47 45	64 43	1838.5	+21.72	......	......	do	do.
Miscou Harbor	48 01	64 30	1838.5	+20.58	......	......	do	do.
Gaspe Basin	48 50	64 30	1846.0	+22.82	......	......	do	do.
Cape Henry, Anticosti	49 48	64 24	1830.0	+24.37	......	......	do	do.
Shediac Island	46 15	64 23	1839.5	+19.98	+2.60	+22.58	do	do.
Cascumpeque	46 48	64 03	1845.5	+21.17	+1.65	+22.82	do	do.
Cape Tormentine	46 10	63 50	1840.5	+20.00	+2.38	+22.38	do	do.
Badeque Harbor	46 24	63 48	1841.5	+20.20	+2.22	+22.42	do	do.
Carleton Head	46 15	63 43	1840.5	+20.30	+2.38	+22.68	do	do.
Richmond Bay	46 34	63 43	1845.5	+21.00	+1.66	+22.66	do	do.
Pugwash Harbor	45 53	63 41	1840.5	+19.67	+2.38	+22.05	do	do.
Wallace Harbor	45 49	63 26	1840.5	+19.83	+2.38	+22.21	do	do.
Cape Turner	46 30	63 20	1845.5	+21.68	+1.66	+23.34	do	do.
Pictou Harbor	45 42	62 40	1841.5	+20.32	+2.00	+22.32	do	do.
Georgetown	46 11	62 33	1843.5	+21.97	+1.70	+23.67	do	do.
Merigomish Harbor	45 38	62 27	1842.5	+20.25	+1.85	+22.10	do	do.
Amherst Harbor	47 15	61 50	1833.5	+22.60	......	......	do	do.
East Point, Anticosti	49 08	61 42	1830.5	+25.32	......	......	do	do.
Bryon Island	47 48	61 26	1835.5	+23.50	......	......	do	do.
Isle Madame	45 35	60 56	1848.5	+22.50	......	......	Keely	do.
Cape Breton	46 17	60 23	1848.5	+23.68	......	......	do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
CANADA, EAST OF LONG. 90°, PART 2—Continued.	° ′	° ′		°	°	°		
Barrie, Lake Simcoe	44 21	79 37	1878.53	+ 4.72	+0.40	+ 5.12	Creswick	MS.
Allondale	44 20	79 41	1879.86	+ 4.80	+0.28	+ 5.08	...do	MS.
Cookstown	44 08	79 37	1880.00	+ 4.06	+0.26	+ 4.32	...do	MS.
Goulais Point	46 42	84 33	1868.5	+ 0.38	+1.06	+ 1.44	Chart	U. S. Lake Sur., 1872.
Sandy Island	46 49	84 38	1868.6	+ 0.25	+1.06	+ 1.31	...do	do.
Waverley	44 47	63 36	1881.8	+21.02	0.00	+21.02	Dawson	MS.
Lawrencetown	44 42	63 22	1881.5	+21.25	0.00	+21.25	...do	MS.
Height of land north of Lake Superior.	48 45	85 05	1874.5	− 1.00	+2.18	+ 1.18	Austin	MS.
Kingston	44 13	76 35	1840.5	+ 4.00	+3.65	+ 7.65		Phil. Trans. Roy. Soc., 1849.
BRITISH POSSESSIONS, WEST OF LONG. 90°, PART 1.								
Waddington Harbor, Bute Inlet	50 54	124 50	1881.58	−25.37	+0.02	−25.35		
Anchorage Cove, B. C	50 53	126 12	1881.59	−25.71	+0.02	−25.69		
North Harbor, B. C	50 29	128 04	1881.73	−24.90	+0.01	−24.89		
Friendly Cove, Nootka Sound, Vancouver Island.	49 36	126 38	1881.74	−23.60	.....	−23.59		
Esquimalt, Vancouver Island	48 25	123 26	1881.75	−22.93	0.00	−22.93		
Departure Bay, Vancouver Island	49 13	123 57	1881.77	−23.93	+0.01	−23.92		
BRITISH POSSESSIONS, WEST OF LONG. 90°, PART 2.								
Port San Juan, Vancouver Island	48 31	124 30	1841.5	−22.50	−0.34	−22.84	Chart	U. S. Expl. Exp'n.
Sumass Prairie	49 01	122 12	1858.5	−21.50	0.00	−21.50	Haig	Phil. Trans. Roy. Soc., 1864.
Schweltza Lake	49 02	122 00	1859.5	−21.62	0.00	−21.62	...do	do.
On Ashtnolou River	49 08	120 00	1860.5	−22.00	0.00	−22.00	...do	do.
Ashtnolou Station	49 00	120 00	1860.5	−22.73	0.00	−22.73	...do	do.
Osoyoos Station	49 00	119 24	1860.5	−22.23	0.00	−22.23	...do	do.
Inshwointum	49 00	118 28	1860.5	−20.28	0.00	−20.28	...do	do.
Wigwam River Station	49 00	114 45	1861.5	−23.87	+0.10	−23.77	...do	do.
Akamina Station	49 01	114 04	1861.5	−23.20	+0.10	−23.10	...do	do.
Station in	50 55	107 29	1860.5	−24.52	+0.30	−24.22	Palliser	N. W. Bound. Com., MS.
do	49 32	115 35	1860.5	−23.57	+0.10	−23.47	Harris	N. W. Bound. Com., chart.
do	49 03	120 55	1860.5	−24.32	0.00	−24.32	...do	do.
do	49 05	121 07	1860.5	−22.38	0.00	−22.38	...do	do.
do	49 01	121 45	1860.5	−22.92	0.00	−22.92	...do	do.
Hecate Bay	49 15	125 56	1861.5	−22.65	0.00	−22.65	Richards	Trans. Roy. Soc., 1872.
Onehucklin Harbor	49 00	125 00	1861.5	−24.22	0.00	−24.22	.. do	do.
Barclay Sound	49 14	124 50	1861.5	−24.62	0.00	−24.62	...do	do.
Namaimo	49 10	124 00	1862.5	−22.95	0.00	−22.95	...do	do.
Whiffen Spit	48 22	123 44	1864.5	−20.33	0.00	−20.33	Pender	do.
Garry Point, Frazer River	49 07	123 11	1864.5	−22.97	0.00	−22.97	...do	do.
New Westminster	49 13	122 53	1862.5	−22.67	0.00	−22.67	Richards	do.
Upper Fort Garry	49 53	97 02	1843.5	−16.00			Lefroy	do.
Halting Place	49 26	94 48	1857.5	−10.28			Palliser	do.
Lake of the Woods	49 28	94 42	1843.5	−12.88			Lefroy	do.
Rainy River	48 48	94 31	1843.5	−13.12			...do	do.
Halting Place	48 50	93 58	1857.5	−11.33			Palliser	do.
Fort Francis	48 37	93 29	1857.5	− 9.52			...do	do.
Rainy Lake	48 32	92 56	1843.5	−11.47			Lefroy	do.
Halting Place	48 27	92 30	1857.5	− 9.88			Palliser	do.
Second Portage	48 15	92 27	1843.5	−10.25			Lefroy	do.
Lake à la Crosse	48 24	92 10	1843.5	− 7.88			...do	do.
Two River Portage	48 35	91 27	1843.5	−11.00			...do	do.
Perch Lake	48 35	91 12	1857.5	− 8.23			Palliser	do.
Savannah Portage	48 53	90 08	1857.5	− 6.88			...do	do.
Kynumft Harbor	52 12	128 12	1866.5	−26.17	+0.10	−26.07	Pender	do.
Safety Cove	51 32	127 57	1864.5	−23.63	+0.05	−23.58	...do	do.
Treadmill Harbor	51 06	127 34	1864.5	−24.13	+0.05	−24.08	...do	do.
Beaver Harbor	50 43	127 25	1866.5	−24.50	+0.04	−24.46	...do	do.
Tracey Harbor	50 51	126 53	1863.5	−26.67	+0.03	−26.64	...do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
BRITISH POSSESSIONS, WEST OF LONG. 90°, PART 2—Continued.	° ′	° ′		°	°	°		
N. Bentinck Arm	52 23	126 48	1864.5	—24.77	+0.05	—24.72	Pender	Trans. Roy. Soc., 1872.
Squirrel Cove	50 08	124 57	1864.5	—23.93	+0.02	—23.91	do	do.
Fort Assiniboine	54 20	114 28	1844.5	—24.65			Lefroy	do.
Saskatchewan River	52 23	107 04	1844.5	—25.35			do	do.
Carlton House	52 51	106 13	1844.5	—22.92			do	do.
Fort Pelly	51 45	102 05	1836.9	—17.00			Simpson	Narr. of Discoveries, etc.
Lake Winnipeg	52 15	97 07	1843.5	—15.62			Lefroy	Trans. Roy. Soc., 1872.
do	51 45	96 53	1843.5	—15.95			do	do.
do	51 04	96 45	1843.5	—14.23			do	do.
do	51 36	96 42	1844.0	—15.70			do	do.
do	50 28	96 35	1857.5	—14.42			Palliser	do.
Fort Alexander	50 37	96 21	1844.0	—14.23			Lefroy	do.
Pinaway Portage	50 12	96 03	1843.5	—12.80			do	do.
Winnipeg River	50 10	95 09	1844.0	—11.92			do	do.
Northwest Territory stations	49 06	113 50	1879.2	—23.37	+0.08	—23.29	Nelson	MS.
do	49 20	113 40	1879.2	—22.98	+0.08	—22.90	do	MS.
do	49 25	113 40	1879.2	—22.97	+0.08	—22.89	do	MS.
do	49 30	113 22	1879.2	—22.60	+0.10	—22.50	do	MS.
do	50 56	114 10	1879.9	—24.50	+0.10	—24.40	do	MS.
do	50 48	113 18	1879.9	—23.00	+0.12	—22.88	do	MS.
do	50 52	114 00	1879.8	—24.32	+0.10	—24.22	do	MS.
do	51 05	115 00	1879.6	—23.97	+0.12	—23.85	do	MS.
do	49 55	111 40	1879.1	—22.40	+0.15	—22.25	do	MS.
do	50 12	110 30	1878.7	—21.92	+0.18	—21.74	do	MS.
do	50 30	110 20	1878.7	—23.23	+0.18	—23.05	do	MS.
do	49 53	112 30	1879.1	—22.77	+0.15	—22.62	do	MS.
do	49 43	112 50	1879.1	—22.47	+0.15	—22.32	do	MS.
Jasper House	53 16	118 10	1871.5	—26.00			Mobesly	MS.
North Thompson River	51 33	120 17	1871.5	—25.50	+0.04	—25.46	Trutch	MS.
do	51 28	120 25	1873.5	—25.33	+0.04	—25.29	Jarvis	MS.
do	51 12	120 22	1871.5	—24.12	+0.04	—24.08	Trutch	MS.
do	50 57	120 28	1871.5	—23.88	+0.04	—23.84	do	MS.
On Little Shushwap	50 50	119 46	1871.5	—24.50	+0.04	—24.46	do	MS.
Thompson River	50 41	120 12	1871.5	—24.00	+0.04	—23.96	do	MS.
do	50 46	121 05	1871.5	—23.50	+0.04	—23.46	do	MS.
Thompson River, mouth of Nicola	50 27	121 22	1871.5	—25.50	+0.04	—25.46	do	MS.
Mouth of Thompson River	50 13	121 36	1871.5	—25.00	+0.03	—24.97	do	MS.
Town of Yale	49 34	121 25	1871.5	—24.00	+0.04	—23.96	do	MS.
Mouth of Hut Creek	50 47	121 33	1873.5	—27.00	+0.03	—26.97	Jarvis	MS.
Head of Howe Sound	49 42	123 09	1873.5	—23.90	+0.04	—23.86	Gamsby	MS.
Clear Water River	52 12	120 12	1873.5	—24.50			Jarvis	MS.
Thompson River, near Kamloops	50 42	120 30	1877.5	—24.25	+0.04	—24.21	Perry	MS.
Port Moorly	49 19	122 50	1881.5	—22.23	+0.04	—22.19	Smith	MS.
Tete Jeanne Cache	52 58	119 50	1876.5	—26.33			Keefer	MS.
North Saskatchewan River	53 23	114 19	1876	—26.50			Ruttan	MS.
Station A	50 42	102 00	1880.39	—18.84			King	MS.
Station B	50 45	101 31	1880.42	—17.18			do	MS.
Station C, Swan River Bar	51 54	101 57	1880.44	—19.62			do	MS.
Station D, Assiniboine River	51 45	102 01	1880.46	—20.21			do	MS.
Station E	51 44	102 29	1880.46	—18.93			do	MS.
Station F	51 42	103 04	1880.47	—19.64			do	MS.
Station G	51 39	103 08	1880.47	—19.56			do	MS.
Station H, on Pelly trail	51 32	103 43	1880.48	—19.87			do	MS.
Station I	51 22	104 00	1880.49	—18.56			do	MS.
Station J	51 12	103 54	1880.50	—19.83			do	MS.
Station K, near fort Qu Appelle	50 46	103 48	1880.51	—19.58			do	MS.
Station L	50 49	104 16	1880.53	—19.18			do	MS.
Station M	50 44	105 14	1880.53	—20.36			do	MS.
Station N	50 47	105 51	1880.54	—20.60			do	MS.
Station O	51 05	106 37	1880.54	—21.31			do	MS.
Station P	50 29	106 47	1880.55	—21.31			do	MS.

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
BRITISH POSSESSIONS. WEST OF LONG. 90°, PART 2—Continued.	° ′	° ′		°	°	°		
Station Q, Reed Lake	50 27	107 22	1880.55	—21.58			King	MS.
Station R, Maple Creek	50 03	108 51	1880.56	—22.00			do	MS.
Station S, the Gap	49 38	109 51	1880.58	—21.73	+0.04	—21.69	do	MS.
Station T	49 40	111 38	1880.60	—21.86	+0.03	—21.83	do	MS.
Station U	49 39	112 18	1880.60	—22.54	+0.03	—22.51	do	MS.
Station V, at Willow Creek	49 45	113 24	1880.63	—22.64	+0.02	—22.62	do	MS.
Station W	50 22	113 49	1880.64	—22.05	+0.03	—22.02	do	MS.
Station X	51 02	114 00	1880.69	—24.22	+0.03	—24.19	do	MS.
Station Z	51 52	114 00	1880.72	—24.26	+0.03	—24.23	do	MS.
Station a, Pipestone Creek	53 04	113 35	1880.73	—25.24	+0.04	—25.20	do	MS.
ALASKAN WATERS, RUSSIAN AND BRITISH POSSESSIONS ADJACENT TO ALASKA TERRITORY, PART 1.								
Plover Bay, East Siberia	64 22	173 22	1880.66	—18.42	+0.78	—17.64		
Big Diomede Island, Behring's Strait.	65 45	169 04	1880.69	—21.82	+0.78	—21.04		
Port McLaughlin, British Columbia.	52 08	128 10	1881.60	—26.72	+0.04	—26.68		
Port Simpson, British Columbia	54 34	130 23	1881.61	—27.90	+0.06	—27.84		
Rose Harbor, Queen Charlotte's Island.	52 09	131 15	1881.72	—26.01	+0.05	—25.96		
ALASKAN WATERS, RUSSIAN AND BRITISH POSSESSIONS ADJACENT TO ALASKA TERRITORY, PART 2.								
Clarence Bay	69 38	140 51	1826.5	—45.72			Franklin	Phil. Trans. Roy. Soc., 1872.
Herschel Island	69 36	139 42	1826.5	—46.22			do	do.
Point Kay	69 18	138 08	1837.53	—49.00			Simpson	Narr. of Discoveries, etc.
Richardson Chain	69 01	137 25	1826.5	—46.68			Franklin	Phil. Trans. Roy. Soc., 1872.
Shoalwater Bay	68 54	136 21	1837.52	—49.37			Simpson	Narr. of Discoveries, etc.
Red River	67 27	133 36	1826.5	—45.62			Franklin	Phil. Trans. Roy. Soc., 1872.
Fort Good Hope	66 16	128 30	1844.5	—42.77			Lefroy	do.
Fort McLeod	55 00	123 11	1875.5	—25.33			Webster	MS.
Camp on Pearl River	55 58	123 13	1875.5	—30.17			do	MS.
Head of Rocky Mountain Portage.	56 03	122 15	1875.5	—28.13			do	MS.
Hudson's Hope	56 02	121 58	1875.5	—26.03			do	MS
Fort Saint John	56 12	121 14	1875.5	—26.00			do	MS.
Forks of Pine River	55 44	121 18	1875.5	—28.83			do	MS.
50 Miles up Skeena River	54 30	128 35	1879.5	—26.50	+0.06	—26.44	Keefer	MS.
31 Miles up Skeena River	54 22	129 00	1879.5	—26.75	+0.06	—26.69	do	MS.
20 Miles up Skeena River	54 19	129 19	1879.5	—27.33	+0.06	—27.27	do	MS.
Skeaux River	54 14	129 47	1879.5	—27.33	+0.06	—27.27	do	MS.
Head of Work Inlet	54 18	129 43	1879.5	—27.50	+0.06	—27.44	do	MS.
Port Essington	54 14	129 47	1879.5	—27.33			do	MS.
Head of Gardner Inlet	53 15	127 37	1875.5	—26.50			Horetzky & Gansby	MS.
Mouth of Chilaccoh River	53 50	123 00	1875.5	—28.25			Bell	MS.
Head of Dean Inlet	52 52	127 13	1876.5	—27.00			Jennings	MS.
Anchor Cove, British Columbia	53 12	132 14	1866.5	—24.98	+0.10	—24.88	Pender	Phil. Trans. Roy. Soc., 1872.
Alpha Bay, British Columbia	53 52	130 18	1866.5	—26.57	+0.12	—26.45	do	do.
Carter Bay, British Columbia	52 50	128 25	1866.5	—25.98	+0.10	—25.88	do	do.
Natschika, Siberia	53 07	202 35	1829.5	— 4.00	+3.26	— 0.74	Erman	do.
Petropavlovsk, Siberia	53 01	201 19	1876.5	— 1.15		— 0.83	Onatzevich	Expl's in Pacific.
Holy Cross Bay, Siberia	65 28	178 32	1828.5	—21.07			Lütke	Phil. Trans. Roy. Soc., 1872.
Wankarem River, Siberia	67 43	176 27	1823.5	—23.00			Wrangel	do.
Kolintchin Island, Siberia	67 27	175 35	1823.5	—23.43			do	do.
At sea	65 47	168 55	1881.41	—22.83	+0.65	—22.18	Hooper	MS.
do	67 17	171 45	1881.41	—22.50	+0.65	—21.85	do	MS.
At sea, off Kolintchin Bay	67 58	175 14	1881.42	—23.50	+0.65	—22.85	do	MS

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
ALASKAN WATERS, RUSSIAN AND BRITISH POSSESSIONS ADJACENT TO ALASKA TERRITORY, PART 2—Continued.	° ′	° ′		°	°	°		
At sea off Koliutchin Bay	66 42	170 46	1881.42	−24.00	+0.65	−23.35	Hooper	MS.
do	66 07	169 17	1881.43	−23.67	+0.65	−23.02	do	MS.
do	65 35	170 45	1881.43	−23.42	+0.65	−22.77	do	MS.
do	64 47	171 35	1881.43	−23.17	+0.65	−22.52	do	MS.
At sea, off Icy Cape	70 15	161 55	1881.55	−32.20	+0.62	−31.58	do	MS.
do	70 05	162 06	1881.56	−32.23	+0.62	−31.61	do	MS.
At sea	69 58	162 38	1881.57	−31.92	+0.62	−31.30	do	MS.
At sea, off Cape Lisburne	68 50	165 10	1881.57	−32.07	+0.62	−31.45	do	MS.
At sea, off Herald Island	70 49	174 32	1881.58	−24.78	+0.62	−24.16	do	MS.
do	70 51	175 40	1881.58	−23.43	+0.62	−22.81	do	MS.
At sea, off Koliutchin Bay	67 52	175 18	1881.60	−19.82	+0.62	−19.20	do	MS.
Wrangell Island, East coast	71 04	177 40	1881.61	−23.43	+0.62	−22.81	do	MS.
Wrangell Island, South coast	70 57	178 10	1881.65	−20.00	+0.62	−19.38	Berry	Hyd. Office.
Off Fort Barrow	71 20	156 15	1881.63	−37.30	+0.61	−36.69	Hooper	MS.
At sea	66 16	161 46	1881.69	−27.05	+0.60	−26.45	do	MS.
Irkaipi	68 50	180 00	1878.7	−17.90	+1.10	−16.80	Wÿkander	Nordenskiöld. (MS. communicated by Dr. Dall, March 12, 1883.)
Pitlekai	67 05	173 30	1878.7	−19.72	+1.10	−18.62	do	do.
Saint Lawrence Bay	65 35	170 41	1879.5	−20.38	+1.00	−19.38	do	do.
Konyam Bay	64 50	172 57	1879.6	−17.87	+1.00	−16.87	do	do.
Saint Lawrence Island	63 43	171 23	1879.6	−19.08	+1.00	−18.08	do	do.
Bering Island	55 14	194 08	1879.6	− 3.93	+0.30	− 3.63	do	do.
At sea	45 33	198 55	1849.5	− 4.50	+1.92	− 2.58	Kellett	Phil. Trans. Roy. Soc., 1872.
do	48 49	201 47	1849.5	− 4.38	+1.92	− 2.46	do	do.
do	47 28	200 15	1849.5	− 4.00	+1.92	− 2.08	do	do.
do	48 34	195 22	1851.5	− 7.17	+1.80	− 5.37	Collinson	do.
do	50 05	201 21	1848.5	− 2.32	+1.99	− 0.33	Kellett	do.
do	50 50	193 23	1850.5	− 5.90	+1.83	− 4.07	Collinson	do.
do	51 54	191 22	1854.5	− 8.60	+1.60	− 7.00	do	do.
do	57 21	183 36	1854.5	−12.67	+2.44	−10.23	do	do.
do	59 32	186 48	1849.5	−10.47	+2.75	− 7.72	do	do.
do	59 38	188 50	1849.5	−10.90	+2.75	− 8.15	Kellett	do.
do	59 05	190 11	1849.5	−10.28	+2.75	− 7.53	do	do.
do	58 19	190 52	1849.5	− 9.68	+2.75	− 6.93	do	do.
do	61 20	182 37	1850.5	−14.12	+2.70	−11.42	Collinson	do.
On the ice	71 34	162 00	1849.57	−37.00	......	......	Kellett	MS. chart.
do	72 50	164 40	1849.56	−42.15	......	......	do	do.
At sea	48 08	146 39	1827.5	−22.58	+1.90	−20.68	Lütke	Phil. Trans. Roy. Soc., 1872
do	48 44	143 23	1827.5	−23.02	+1.90	−21.12	do	do.
do	51 46	152 36	1830.5	−24.08	+1.60	−22.48	Erman	do.
do	45 19	160 00	1850.0	−17.77	+1.50	−16.27	Kellett	do.
do	45 14	159 41	1850.0	−18.75	+1.50	−17.25	do	do.
WEST INDIA ISLANDS AND MEXICO, EAST OF LONG. 100°, PART 1.								
Nassau, New Providence	25 06	77 20	1879.14	− 1.43	+0.35	− 1.08		
South Bemini, Bahama Islands	25 42	79 18	1879.15	− 2.46	+0.38	− 2.08		
Water Cay, Salt K. B	23 59	80 21	1879.16	− 2.84	+0.35	− 2.49		
Matanzas, Cuba	23 03	81 37	1879.18	− 3.44	+0.22	− 3.22		
Havana, College de Belen	23 08	82 21	1879.20	− 3.00	......	− 3.90		
Bahia Honda, Cuba	22 58	83 12	1879.24	− 4.06	+0.22	− 3.84		
Cape San Antonio, Cuba	21 56	84 55	1879.27	− 4.73	+0.22	− 4.51		
Belize, British Honduras	17 29	88 12	1879.29	− 5.79	......	......		
Cozumel Island	20 33	86 57	1879.32	− 5.20	+0.30	− 4.90		
Mugeres Island	21 15	86 46	1879.32	− 4.82	+0.30	− 4.52		
Perez Island, off Yucatan	22 24	89 42	1880.06	− 6.32	+0.30	− 6.02		
Arenas Cay, off Yucatan	22 07	91 25	1880.08	− 6.55	+0.32	− 6.23		
Vera Cruz, Mexico	19 12	96 08	1880.11	− 7.44	......	− 6.60		
Coatzacoalcos, Mexico	18 08	94 26	1880.14	− 7.18	+0.44	− 6.74		
Laguna de Terminos, Mexico	18 38	93 00	1880.17	− 6.66	+0.44	− 6.22		

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
WEST INDIA ISLANDS AND MEXICO, EAST OF LONG. 100°, PART 1—Continued.	° ′	° ′		°	°	°		
Campeche, Yucatan	19 50	90 33	1880.19	− 6.61	+0.35	− 6.26		
Progresso, Yucatan	21 17	89 40	1880.20	− 6.43	+0.30	− 6.13		
La Union, San Salvador	13 17	87 46	1880.84	− 5.98				
Acajutla, San Salvador	13 34	89 51	1880.85	− 6.26				
Champerico, Guatemala	14 18	91 55	1880.86	− 7.01				
Salina Cruz, Tehuantepec	16 10	95 27	1880.87	− 7.29				
Port Escondido, Mexico	16 04	96 57	1880.88	− 7.70	+0.30	− 7.40		
Acapulco, Mexico	16 49	99 56	1880.90	− 7.94		− 7.61		
WEST INDIA ISLANDS AND MEXICO, EAST OF LONG. 100°, PART 2.								
Kingston, Port Royal	17 56	76 51	1876.0	− 3.79				Eng. Admiralty ch.
Lerma, Yucatan	19 49	90 34	1847.5	− 8.03			Barnett	Phil. Trans. Roy. Soc., 1874.
South Key, Honduras Bay	16 03	86 59	1844.5	− 7.75			Lawrence	do.
Point Morant, Jamaica	17 55	76 16	1831.5	− 5.22			Austin	do.
Cumberland Harbor, Cuba	19 55	75 15	1837.5	− 3.52			Milne	do.
Saint Iago, Cuba	20 00	76 03	1837.5	− 3.65			...do	do.
Barracon, Cuba	20 22	74 34	1831.5	− 3.28			Austin and Foster	do.
Watling Island	23 57	74 25	1831.5	− 2.52			Smith	do.
Crooked Island, Bahama Islands	22 07	74 24	1835.5	−5.22 (?)			Foster	do.
do	22 47	74 21	1837.5	− 2.57			Milne	do.
Cape Maiye, Cuba	20 14	74 12	1831.5	− 2.45			Austin	do.
Potrero, Mexico	18 56	96 48	1856.63	− 8.65	+2.04	− 6.61	Sonntag	Smith'n Cont's, 1860.
Cocolopam, Orizaba	18 53	97 04	1856.65	− 8.47	+2.04	− 6.43	...do	do.
San Andres, Chalchecomula	18 59	97 15	1856.71	− 8.22	+1.75	− 6.47	...do	do.
Mirador, Mexico	19 13	96 37	1856.77	− 8.03	+2.03	− 6.00	...do	do.
City of Mexico	19 26	99 07	1879.85	− 8.58		− 7.40	Reyes	Mem. Dep. Mag. del Obs. Metr. Cent.
Chalco	19 18	98 51	1857.02	− 9.05	+1.16	− 7.89	Sonntag	Smith'n Cont's, 1860.
Tlamacas	19 03	98 39	1857.07	− 8.47	+1.16	− 7.31	...do	do.
MEXICO, WEST OF LONG. 100°, PART 1.								
San Martin Island, Lower California.	30 29	116 07	1881.24	−12.93	− 0.09	−13.02		
Lagoon Head, Lower California	28 14	114 06	1873.12	−11.85	−0.28	−12.13		
Cerros Island, Lower California	28 03	115 11	1881.19	−11.98	−0.09	−12.07		
San José del Cabo, Lower California.	23 04	109 41	1881.13	− 9.73	−0.02	− 9.75		
Magdalena Bay, Lower California	24 38	112 09	1881.15	−10.48		−10.80		
Ascension Island, Lower California.	27 06	114 18	1881.18	−11.38	−0.08	−11.46		
Clarion Island	18 20	114 42	1880.77	− 8.38	−0.10	− 8.48		
Socorro Island	18 43	110 54	1880.78	− 8.83	−0.05	− 8.88		
Isla Grande, Mexico	17 40	101 41	1880.91	− 7.44	+0.15	− 7.29		
Manzanilla, Mexico	19 03	104 20	1880.92	− 8.08	+0.12	− 7.96		
San Blas, Mexico	21 32	105 18	1880.93	− 9.30		− 9.10		
Point San Ignacio, Mexico	25 36	109 17	1880.97	−10.26	−0.03	−10.29		
Santa Barbara Bay, Mexico	26 42	109 38	1880.98	−10.81	−0 03	−10.84		
Guaymas, Mexico	27 55	110 53	1880.99	−11.80	−0.07	−11.87		
Tiburon Island, Mexico	29 12	112 27	1881.00	−11.99	−0.08	−12.07		
Rocky Point, Mexico	31 17	113 33	1881.01	−13.45	−0.09	−13.54		
Philipps Point, mouth of River	31 46	114 43	1881.02	−13.10	−0.09	−13.19		
Point San Felipe, Lower California.	31 02	114 50	1881.04	−12.95	−0.09	−13.04		
San Luis Gonzales, Lower California.	29 51	114 25	1881.04	−12.46	−0.09	−12.55		
Santa Teresa Bay, Mexico	28 25	112 52	1881.05	−11.70	−0.08	−11.78		

Table of Magnetic Declinations, etc.—Continued.

Station.	ϕ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
MEXICO, WEST OF LONG. 100°, PART 1—Continued.	° ′	° ′		°	°	°		
Santa Maria Cove, Lower California.	27 25	112 20	1881.06	—11.10	—0.08	—11.18		
Mulege, Lower California	26 54	111 58	1881.07	—11.22	—0.08	—11.30		
Loreto, Lower California	26 01	111 20	1881.08	—10.27	—0.07	—10.34		
Isle San Josef, Lower California	24 55	110 37	1881.09	— 9.79	—0.06	— 9.85		
Pichilingue Bay, Lower California	24 16	110 20	1881.10	— 9.75	—0.05	— 9.80		
La Paz, Lower California	24 10	110 21	1881.10	—10.15	—0.05	—10.20		
Mazatlan, Mexico	23 12	106 27	1881.12	— 9.66	+0.06	— 9.60		
Cape San Lucas, Lower California.	22 54	109 55	1881.14	— 9.44	—0.03	— 9.47		
Pequeña Bay, Lower California	26 16	112 28	1881.16	—10.52	—0.08	—10.60		
Point Abreojos, Lower California	26 47	113 31	1881.17	—11.26	—0.09	—11.35		
Guadalupe Island, Lower California.	28 55	118 15	1881.21	—12.91	—0.12	—13.03		
San Geronimo, Lower California	29 47	115 48	1881.23	—12.70	—0.10	—12.80		
Todos Santos, Lower California	31 51	116 38	1881.26	—12.01	—0.10	—12.11		
MEXICO, WEST OF LONG. 100°, PART 2.								
Presidio del Norte	29 34	104 25	1852.5	—10.27	0.00	—10.27	Emory	Bound. Sur.
San Quentin, Lower California	30 22	115 59	1873.67	—13.00	—0.30	—13.30	Tanner & Young	Cruise of Narragansett.
San Bartholomew	27 40	114 54	1873.70	—12.13	—0.27	—12.40	... do	do.
Mouth of Rio Colorado	31 51	116 05	1841.5	—11.25	—1.36	—12.61	Duflot de Mofras	Expl'n of Oregon.
La Playa, Maria Bay	28 55	114 32	1874.97	—11.36	—0.24	—11.60	Craig & Seymour	Cruise of Narragansett.
San Benito Peak	28 18	115 36	1874.98	—11.30	—0.24	—11.54	....do	do.
San Ignacio Point	26 46	113 16	1875.01	—12.13	—0.23	—12.36	... do	do.
San Domingo Point	26 19	112 42	1875.01	—10.36	—0.22	—10.58	....do	do.
San Juanico Point	26 03	112 40	1875.02	—10.82	—0.22	—11.04	Reiter	do.
Boca Soledad	25 16	112 08	1875.02	—11.13	—0.21	—11.34	....do	do.
Santa Maria Bay	24 45	112 16	1875.03	—10.76	—0.21	—10.97	Craig	do.
El Conejo Point	24 21	111 30	1875.04	—10.27	—0.20	—10.47	Reiter and Craig	do.
Todos Santos	23 24	110 14	1875.04	— 9.23	—0.12	— 9.35	Reiter	do.
Observation Point	23 33	109 29	1875.05	— 9.96	—0.10	—10.06	....do	do.
Punta Arena	24 04	109 50	1875.06	—10.10	—0.10	—10.20	....do	do.
Espiritu Santo Island	24 24	110 21	1875.06	— 9.43	—0.15	— 9.58	Craig and Reiter	do.
San Marcial Point	25 29	111 02	1875.10	—10.18	—0.20	—10.38	Reiter	do.
Pulpito Point	26 31	111 27	1875.11	—11.56	—0.21	—11.77	....do	do.
San Marcos Island	27 10	112 06	1875.12	—10.63	—0.22	—10.85	Craig and Reiter	do.
San Carlos Point	28 00	112 48	1875.13	—11.76	—0.23	—11.99	....do	do.
Las Animas	28 48	113 13	1873.92	—12.59	—0.27	—12.86	Tuttle and Young	do.
Angel de la Gardia Island	29 00	113 12	1875.14	—12.48	—0.24	—12.72	Craig and Reiter	do.
do	29 32	113 30	1875.15	—12.53	—0.25	—12.78	Reiter	do.
George's Island	31 01	113 17	1875.20	—12.72	—0.26	—12.98	Reiter & Seymour	do.
Sepoca Bay	30 16	112 53	1875.20	—12.28	—0.25	—12.53	Reiter	do.
Raza Island	28 49	113 00	1875.21	—12.50	—0.24	—12.74	Reiter and Craig	do.
Punta Mita	20 46	105 32	1875.34	— 9.06	+0.13	— 8.93	Craig & Seymour	do.
San Everisto	24 52	110 42	1873.84	— 8.88	—0.22	— 9.10	Seymour & Young	do.
Carmen Island	26 00	111 07	1873.86	—11.46	—0.23	—11.69	Tuttle and Young	do.
Angeles Bay	28 57	113 35	1873.92	—12.69	—0.27	—12.96	....do	do.
Remedios Bay	29 14	113 40	1873.93	—12.56	—0.27	—12.83	....do	do.
Mejia Island	29 33	113 35	1875.15	—12.08	—0.25	—12.33	Reiter & Seymour	do.
San Luis Island	29 58	114 26	1873.96	—12.50	—0.28	—12.78	Tuttle and Young	do.
Adair Bay	31 30	114 08	1873.97	—13.33	—0.29	—13.62	... do	do.
Libertad Bay	29 54	112 45	1873.98	—12.93	—0.28	—13.21	....do	do.
Patos Island	29 16	112 29	1873.98	—13.00	—0.28	—13.28	....do	do.
Tiburon Island	28 46	112 22	1873.99	—12.47	—0.27	—12.74	....do	do.
Kino Bay	28 46	111 59	1873.99	—12.55	—0.25	—12.80	... do	do.
San Pedro Anchorage	28 03	111 16	1874.00	—12.41	—0.25	—12.66	.. do	do.
Off Lobos Island	27 20	110 38	1874.06	—11.51	—0.23	—11.74	....do	do.
Ciaris Island	26 59	109 57	1874.06	—11.27	—0.20	—11.47	....do	do.

Table of Magnetic Declinations, etc.—Continued.

Station.	φ	λ	t	D	ΔD	$D_{1885.0}$	Observer.	Reference.
MEXICO, WEST OF LONG. 100°, PART 2—Continued.	° ′	° ′		°	°	°		
Agiabampa	26 17	109 18	1874.07	−12.02	−0.17	−12.19	Tuttle & Young	Cruise of Narragansett.
Topolobampa	25 34	109 10	1874.08	−10.68	−0.15	−10.83	....do	do.
Norachista	25 23	108 49	1874.08	−10.34	−0.12	−10.46	....do	do.
Playa Colorado	25 12	108 24	1874.08	−10.68	−0.10	−10.78	....do	do.
Peñas Anchorage	20 36	105 16	1874.17	− 8.83	+0.13	− 8.70	Seymour & Young	do.
Tabo Bay	20 24	105 40	1874.18	− 8.90	+0.13	− 8.77		do.
Near Benedicte Island	19 15	110 49	1874.24	− 9.10	−0.05	− 9.15		do.
Near Roca Partita	19 06	112 00	1874.24	− 8.35	−0.05	− 8.40		do.
Isabel Island	21 56	105 41	1874.14	− 9.40	+0.13	− 9.27		do.

APPENDIX No. 14.

RECORDS AND RESULTS OF MAGNETIC OBSERVATIONS MADE AT THE CHARGE OF THE "BACHE FUND" OF THE NATIONAL ACADEMY OF SCIENCES, FROM 1871 TO 1876.

Under the direction of J. E. HILGARD, M. N. A. S.

In 1871, the income of the fund left in trust by Professor Alexander Dallas Bache to the National Academy of Sciences, for the prosecution of scientific research, became available for its objects. In view of the great interest always manifested by Professor Bache in the furtherance of investigations relating to terrestrial magnetism, and of the need of a systematic determination of the magnetic elements at many stations in the interior of the United States, I submitted to the Board of Direction of the Fund, in April of that year, a proposition for a magnetic survey, which, after due consideration, was formally approved by the Board.

The details of the plan are given in the following

PROJECT OF A MAGNETIC SURVEY IN THE INTERIOR OF THE UNITED STATES, TO BE MADE UNDER THE DIRECTION OF J. E. HILGARD, M. N. A. S.

1. The magnetic declination, dip, and horizontal intensity will be observed at as many stations as practicable, so distributed as to furnish, together with the observations made in the Coast Survey, and other reliable data, the means of constructing a general magnetic chart of the country east of the Mississippi.

2. The stations will be selected nearly with reference to the want of reliable determinations. Some of the places, at which good observations have heretofore been made, will be reoccupied in order to obtain the rate of secular variation.

3. The instruments will be supplied from the Coast Survey Office.

4. The expenditure for the field-work is authorized on the following basis: The observer will receive an allowance of $3 per day for his services, and of $2 for subsistence. The necessary expenses of transportation for himself and instruments, and the occasional hire of assistance, will constitute the other items of account.

5. The following is an estimate of monthly expenditure for the field-work, which is estimated to yield on the average eight stations:

Pay for services of observer, at $3 per day	$90
Allowance for subsistence, at $2 per day	60
Transportation of observer and instruments	50
Contingent expenses, hire of assistance, &c	25
Total	225

6. The treasurer is authorized to make advances of funds for the prosecution of the work to an amount not exceeding $1,500 in the aggregate, to Mr. J. E. Hilgard, who will render accounts under the heads comprised in the estimate, and who will also require monthly reports of progress to be made by the observer, which he will lay before the Board.

7. When the field-work has sufficiently progressed, special provision will be made for the discussion of the material and the construction of a map.

Approved.

JOSEPH HENRY.
LS. AGASSIZ.
BENJAMIN PEIRCE.

AUGUST 9, 1871.

Observers having been trained under my special direction, and furnished with detailed instructions for the work, it was begun by the occupation of nine stations in 1871-'72, and continued by direction of the Board during parts of successive years, ending in August, 1876. In all, one hundred and forty stations were occupied; at one hundred and thirty-four of these, determinations of the magnetic declination were made, and at ninety-two of them results were also obtained for the dip and horizontal intensity. The data have been collated, field computations revised, and full abstracts prepared under my direction by H. W. Blair, Assistant Coast and Geodetic Survey.

The abstracts are presented with the reductions, in tabular form for convenience of reference, omitting all details not essential to the comprehension of the records. Careful verification has been made of the results by independent computations.

The table of final results, giving the names of the stations occupied, with their geographical positions, will indicate the large area over which the work extended. By combining the results for declination at these stations with the similar data available in the Coast Survey archives, and from other sources, I was enabled to construct a chart of isogonic lines in the United States for the year 1875, and thus to meet in some measure the great and constantly increasing demand for information relative to the variation of the compass. This chart was published as an illustration to Appendix No. 21, Coast Survey Report for 1876.

MAGNETIC SURVEY.

1871-'72.

DESCRIPTIONS OF STATIONS.

COLUMBUS, OHIO.—The station is in the State-house grounds, but in just which part of them does not appear from the record.

RICHMOND, IND.—The station was in the garden of Dr. Plummer, whose residence is No. 31 Front Street, near corner of Walnut (between Main and Walnut Streets).

NEW ALBANY, IND.—The station is on hill on Paola Road, below sandstone quarries, and directly above negro graveyard, two miles northwest of court-house.

EDGEFIELD, TENN.—The station is in middle of southwest quarter of grounds in front of Settle's estate, known as "the old Whitmore Place," now Saint Alban's.

CORINTH, MISS.—The station is on low ground in an enclosed pasture (equilateral triangle) northwest of junction, northeast of railroad cut, between old forts.

OXFORD, MISS.—The station is on flat hill-top (base-ball grounds) south of Campus of University.

GRENADA, MISS.—The station is northwest of town, beyond sand ravines, southeast of J. S. Ladd's property.

MAGNOLIA BASE, LOUISIANA.—This is the Magnolia Base of the United States Coast Survey. What part was taken for the magnetic station is not stated.

NEW ORLEANS, LA.—The first station at New Orleans was in the City Park. The second station was in a wet pasture in the fair-grounds, and was laid down in the presence of Mr. C. E. Thompson (son of General Jeff. Thompson) and Mr. Stithe.

SOUTHWEST PASS, LOUISIANA.—The first station is on island west of Stake Island, about 4 feet above water, overgrown with shrubs. The second station is on a small island, about 1¼ miles west of (old) light-house at Southwest Pass.

OSGOOD'S ISLAND, LOUISIANA.—The island is the property of George Osgood, and is southeast by east of Pass à l'Outre Light-house.

PETITE ANSE, AVERY'S ISLAND, LOUISIANA.—The island is 6 or 7 miles southwest of New Iberia. The station is on a ridge southeast of mansion. It is marked by a quartz stone with notch, which was placed in position in presence of Dudley Avery, esq., and Mr. Edmund McIlhaney.

BRASHEAR CITY, LA.—A few blocks above the railroad depot and steamboat landing. North of the town, the old earthworks stretch about east and west. The station is on the most northerly corner of a polygonal bastion surrounded by a bridged moat.

BATON ROUGE, LA.—The station is on a mound south of college, beyond drain, to the right of street or road leading up hill; marked by a marble rock known to members of faculty.

GRAND ECORE, LA.—Grand Ecore is on Red River, near Natchitoches, on an elevated sandy bluff. The station is in front of Dr. T. S. Collier's hotel, and is marked by a flagstone in a semicircular breastwork.

SHREVEPORT, LA.—The station is on the river front of Jones' Hill, lower end, opposite second frame house. It is marked by a sandstone set edgewise and resembling a brick side; cross-mark on stone.

LONGVIEW, TEX.—The station is north of depot, in an open space, marked by a dark-colored cake of sandstone, which was set in the presence of Dr. J. H. Adams.

ALEXANDRIA, LA.—The station is in a pasture called "Irwin's pasture," about southeast of the corner of Fourth and Casson Streets, and to the rear of the Catholic church. The pasture is enclosed by a board fence, and is crossed nearly in the middle by a ditch with a levee on each side. The station is on the northeast (or river side) levee, and about two-thirds across the pasture from the Casson Street side; it is marked by a brick-stone set into the levee.

NATCHEZ, MISS.—The station is on the bluff at north end of town on Frank Singet's, opposite new Jewish burying grounds. Charles C. Nauck, city surveyor, was present when station was selected. The reference mark is the cross of the Cathedral.

VICKSBURG, MISS.—The station is on Castle Hill, south end of bluff, east of school-house, and marked by a brick-stone and notch. References: Rev. C. K. Marshall, A. L. Peirce, city engineer, Mr. Max Kuner, watchmaker, J. M. Searles, C. E., formerly of the Coast Survey. The mark is the southwest edge of masonry of upper tier of Cathedral steeple.

MONROE, LA.—No description of station is given, but there is a reference to J. W. Green, superintendent Monroe Railroad.

JACKSON, MISS.—The station is on an old bald spot in rear of free school, northeast of State-house. The "mark" is the cross on a church to southwest.

MEMPHIS, TENN.—No description given.

GOLCONDA, ILL.—No description given.

CAIRO, ILL.—No description given.

SAINT LOUIS, MO.—The first station is on the premises of Jul. Pitzman, esq. (mansion No. 1900 South Compton Avenue). Station in grounds south of house. By measurement on city map the station is about 13,060 feet from centre of court-house, and about 5,700 feet in latitude south of court-house. Distance between centre of court-house and Marine Hospital (map measurement), 16,390. The following bearings were noted.

	°	′
Pitzman's house (southeast edge wall of main building, not wing)	10	08
Court-house	63	09
Saxon church	93	14
Marine hospital	152	31
Franciscan convent	182	29

The second station is in street adjoining Pitzman's field on the south; it is in the meridian of the first station. The second station is not preserved, the street in question being in process of grading.

The third station is in a vacant lot about 7,000 feet south and 5,000 feet west of court-house, in the angle of Dubeneil and Linn Streets (at their meeting with Geyer Avenue), and close to Payne's Addition.

DUBUQUE, IOWA.—The station is on Seminary Hill, on the estate of George D. Wood, looking southward. The "mark" is Romberg's pavilion.

WENONA, MARSHALL COUNTY, ILLINOIS.—The station is on premises of J. R. Cowen, five blocks west of Illinois Central Railroad, two blocks south of cross railroad. Stone set in presence of Mr. Cowen.

MACON, ILL.—The station is on granite bowlder in pasture, east of premises of R. H. Woodcock. The "mark" is the cross on church.

HIGHLAND, MADISON COUNTY, ILLINOIS.—The station is at an old stone (corner stone) on commons south of depot. Reference: A. F. Bandelier, esq., banker.

HERMANN, MO.—The station is on hill top southeast of depot and west of Klink's, southeast of Plust's Hill, once occupied by General Marmaduke's forces. Reference: William C. Boeing, near station.

SEDALIA, MO.—The station is on George Husman's nursery grounds, three-quarters of a mile south of depot.

KANSAS CITY, MO.—No description given.

MANHATTAN, KANS.—The station is in the college grounds, east of main building.

ELLIS, KANS.—No description given.

WALLACE, KANS.—No description given.

DENVER, COLO.—The station is on "General Pierce's block," owned by L. F. Barteler, esq.

PUEBLO, COLO.—No description given.

CHEYENNE, WYO.—No description given.

SYDNEY, NEBR.—No description given.

NORTH PLATTE, NEBR.—No description given.

GRAND ISLAND, NEBR.—The station is in northwest corner of slaughter-yard, three-quarters of a mile northwest of depot.

OMAHA, NEBR.—The station is on hill top southwest of Brownell School.

DES MOINES, IOWA.—The station is in lot of Judge P. M. Casady, on Chestnut Street, between Fifth and Sixth Streets.

1871-'72.

OBSERVATIONS FOR DECLINATION.

STATIONS.

Columbus, Ohio.	Baton Rouge, La.	Saint Louis, Mo.	Ellis, Kans.
Richmond, Ind.	Grand Ecore, La.	Dubuque, Iowa.	Wallace, Kans.
Edgefield, Tenn.	Shreveport, La.	Wenona, Ill.	Denver, Colo.
Corinth, Miss.	Longview, Tex.	Macon, Ill.	Pueblo, Colo.
Grenada, Miss.	Alexandria, La.	Highland, Ill.	Cheyenne, Wyo.
Magnolia Base, La.	Natchez, Miss.	Hermann, Mo.	Sydney, Nebr.
New Orleans, La.	Vicksburg, Miss.	Sedalia, Mo.	North Platte, Nebr.
Southwest Pass, La.	Monroe, La.	Kansas City, Mo.	Grand Island, Nebr.
Osgood's Island, La.	Jackson, Miss.	Manhattan, Kans.	Omaha, Nebr.
Avery's Island, La.	Golconda, Ill.	Salina, Kans.	Des Moines, Iowa.
Brashear City, La.			

Observer, T. C. HILGARD.

EXPLANATION OF TABLE.

1. The first column gives the date of the observations for azimuth.
2. The second column gives the observed zenith distance of the sun's limb corrected for semi-diameter, parallax, and refraction.
3. The third column gives the azimuth of ⊙, corresponding to the zenith distance given in second column.
4. The fourth column gives the corresponding reading of the ⊙ on the horizontal circle.
5. The difference between the quantities in the third and fourth columns give those in the fifth.
6. In the sixth column are given the readings of the mark, corresponding to the reading of the ⊙ given in column 4.
7. The quantities in the seventh column are the differences between those in the fifth and sixth columns.

8. In the ninth column are the measured angles between the "mark" and the "magnetic meridian" or axis of the collimator magnet. Very frequently these angles were measured at different times from the observations for azimuth.

9. Column 10 results from the difference between columns 8 and 9.

10. Finally, column 12 gives the dates of the observations for declination.

The above applies to the reduction of the declination observations of 1873 and 1876, and, with the exception of the second column, to those of 1874. In the latter the observed altitude of the limb is given uncorrected for semi-diameter and refraction.

OBSERVATIONS FOR DECLINATION.

Magnetic Survey, 1871–'72.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
COLUMBUS, OHIO. $\phi = 39° 58'$.											
1871. Nov. 18, p.m.	83 59.1	121 24.4	191 38.9	313 03.3	237 48.0	284 44.7	284 44.7	76 30.0	1 14.7	E.	Nov. 18, p.m.
COLUMBUS, OHIO, DEAN'S MAGNETIC STATION. $\phi = 39° 57'.7$.											
							*0 00.0	1 10.8	1 10.8	E.	Nov. 20, a.m.
RICHMOND, IND. $\phi = 39° 50'$.											
Nov. 24, a.m.	71 36.4	139 24.0	316 22.3	176 58.3	170 14.2	353 15.9	353 15.9	10 00.2	3 16.1	E.	Nov. 24, a.m.
EDGEFIELD, TENN. $\phi = 36° 14'$.											
Dec. 1, p.m.	79 49.3	126 54.6	228 07.4	355 02.0	10 57.0	15 55.0	15 55.0	10 53.0	5 02.0	E.	Dec. 1, p.m.
CORINTH, MISS. $\phi = 34° 56'$.											
Dec. 3, p.m.	72 01.1	135 15.2	38 57.9	174 13.1	84 23.9	270 10.8	....	95 18.3	5 41.1	E.	Dec. 3, p.m.
3, p.m.	78 54.4	127 16.4	46 14.4	173 30.8	84 05.6	270 34.8	270 22.8	95 35.9	5 58.7	E.	3, p.m.
									5 49.9	E.	
GRENADA, MISS. $\phi = 33° 47'$.											
1872. Jan. 11, p.m.	77 21.9	127 28.0	226 11.5	353 39.5	354 26.0	0 46.5	0 46.5	5 44.5	6 31.0	E.	Jan. 11, p.m.
Apr. 29, p.m.	80 17.7	78 39.4	274 52.6	353 32.0	39 50.8	46 18.8	....	40 01.0	6 18.2	E.	Apr. 29, p.m.
29, p.m.	85 17.4	75 22.0	278 09.3	353 31.3	39 50.8	46 19.5	46 19.2	39 53.1	6 26.1	E.	30, a.m.
									6 25.1	E.	
MAGNOLIA BASE, LA. $\phi = 29° 32'.5$.											
								39 02.4	6 46.5	E.	Jan. 18, p.m.
								39 02.4	6 46.5	E.	19, p.m.
								39 00.0	6 44.1	E.	20, p.m.
							†327 44.1	39 05.9	6 50.0	E.	21, a.m.
									6 46.8	E.	
NEW ORLEANS, LA., CITY PARK STATION. $\phi = 29° 57'$.											
Feb. 10, p.m.	73 15.0	118 07.6	235 38.5	353 46.1	360 12.2	6 26.1	‡6 26.1	+ 0 13.8	6 39.9	E.	Feb. 10, p.m.
12, p.m.	76 22.9	114 50.0	239 27.4	354 17.4	365 55.0	11 37.6	11 37.6	− 4 57.9	6 39.7	E.	12, p.m.
									6 39.8	E.	

* Astronomical meridian mark. † Azimuth of base from C. S. computations. ‡ Evidently changed the mark.

Observations for Declination—Continued.

NEW ORLEANS, LA., FAIR GROUNDS STATION. $\phi = 29° 59'.1$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
1872.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
Feb. 14, p.m.	76 12.7	114 06.4	239 20.6	353 27.0	8 30.2	15 03.2					
14, p.m.	80 24.7	111 07.2	242 14.2	353 21.4	8 30.0	15 08.6	....	8 24.2	6 40.4	E.	Feb. 14, p.m.
15, p.m.	63 55.6	124 16.4	228 56.5	353 12.9	8 13.5	15 00.6	....	8 29.0	6 35.6	E.	15, p.m.
Mar. 11, p.m.	76 51.4	101 41.0	251 49.5	353 30.5	8 36.4	15 05.9	15 04.6	8 22.1	6 42.5	E.	Mar. 11, p.m.
									6 39.5	E.	

SOUTHWEST PASS, LA., FIRST STATION. $\phi = 28° 59'$.

Mar. 2, p.m.	60 44.8	117 45.2	235 11.3	352 56.5	280 23.2	287 26.7	287 26.7	78 38.7	6 05.4	E.	Mar. 2, p.m.

SOUTHWEST PASS, LA., SECOND STATION.

Mar. 3, a.m.	62 42.8	115 37.2	288 39.7	173 02.5	80 17.0	267 14.5	267 14.5	100 04.0	7 18.5	E.	Mar. 3, a.m.

OSGOOD'S ISLAND, LA. $\phi = 29° 11'.0$.

Mar. 4, p.m.	77 29.1	104 17.2	250 00.0	354 17.2	145 07.2	150 50.0	....	144 28.7	6 17.1	E.	Mar. 4, p.m.
5, a.m.	61 08.8	116 03.6	110 06.0	354 02.4	144 44.0	150 41.6	150 45.8	144 41.4	6 04.4	E.	5, a.m.
									6 10.7	E.	

PETITE ANSE, AVERY'S ISLAND, LA. $\phi = 29° 55'$.

Mar. 13, p.m.	81 47.5	97 40.4	254 59.9	352 40.3	304 29.8	311 49.5	....	55 32.6	7 20.8	E.	Mar. 13, p.m.
14, p.m.	83 40.9	96 05.0	256 47.3	352 52.3	304 40.7	311 48.4	....	55 30.0	7 18.2	E.	14, p.m.
19, p.m.	81 12.3	95 15.6	257 21.8	352 37.4	304 24.2	311 46.8	311 48.2	55 32.6	7 20.8	E.	16, p.m.
								55 30.8	7 19.0	E.	19, p.m.
									7 19.7	E.	

BRASHEAR CITY, LA. $\phi = 29° 41'$.

Mar. 23, p.m.	72 38.2	98 28.8	254 40.1	353 08.9	300 00.5	306 51.6					
23, p.m.	76 50.9	95 54.6	257 12.8	353 07.4	300 00.0	306 52.6	306 52.1	60 01.0	6 53.1	E.	Mar. 23, p.m.

BATON ROUGE, LA. $\phi = 30° 26'$.

Apr. 6, p.m.	79 15.7	88 17.6	264 00.0	352 17.6	353 41.0	1 23.4	....	5 34.9	6 57.5	E.	Apr. 1.
6, p.m.	86 18.3	84 11.6	268 07.4	352 19.0	353 40.8	1 21.8	1 22.6	5 39.0	7 01.6	E.	6, p.m
									6 59.5	E.	

GRAND ECORE, LA. $\phi = 31° 48'$.

Apr. 10, a.m.	74 53.9	89 39.6	81 30.3	351 50.7	107 49.1	115 58.4					
10, p.m.	75 48.3	88 53.2	263 07.1	352 00.3	108 03.7	116 03.4					
10, p.m.	78 06.5	87 28.0	264 27.6	351 55.6	108 03.7	116 08.1	....	108 07.6	7 55.8	E.	Apr. 10, a.m.
10, p.m.	81 02.6	85 40.6	266 19.3	351 50.9	108 03.7	116 03.8	116 03.4	108 14.3	7 49.1	E.	10, p.m.
									7 52.4	E.	

SHREVEPORT, LA. $\phi = 32° 30'$.

Apr. 14, p.m.	85 05.1	81 28.8	270 30.6	351 59.4	67 53.4	75 54.0	75 54.0	67 53.9	8 00.1	E.	Apr. 14, p.m.

LONGVIEW, TEX. $\phi = 32° 29'$.

Apr. 15, p.m.	74 22.6	92 15.0	263 44.8	171 29.8	267 13.1	95 43.3					
Apr. 15, p.m.	77 06.6	93 57.4	265 26.7	171 29.3	267 13.1	95 43.8	95 43.6	87 05.8	8 37.8	E.	Apr. 15, a.m.

Observations for Declination—Continued.

ALEXANDRIA, LA. $\phi = 31° 17'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
1872.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
Apr. 18, a.m.	76 19.6	85 16.4	257 44.1	172 27.7	152 44.5	340 16.8					
18, a.m.	74 06.6	86 34.8	258 57.5	172 22.7	152 42.5	340 19.8					
18, a.m.	71 40.3	88 01.4	260 23.5	172 22.1	152 42.0	340 19.9					
18, a.m.	70 28.3	88 44.4	261 15.5	172 31.1	152 45.0	340 13.9	340 17.6	27 26.3	7 43.9	E.	Apr. 18, a.m.

NATCHEZ, MISS. $\phi = 31° 34'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Apr. 22, p.m.	83 34.0	79 10.8	273 32.1	352 42.9	4 31.8	11 48.9	....	4 34.6	7 12.5	E.	Apr. 21, p.m.
22, p.m.	86 10.3	77 35.8	275 12.0	352 47.8	4 33.1	11 45.3	11 47.1	4 30.0	7 17.1	E.	22, p.m.
									7 14.8	E.	

VICKSBURG, MISS. $\phi = 32° 23'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Apr. 24, a.m.	78 14.8	81 52.6	74 27.7	352 35.1	360 06.0	7 30.9					
24, p.m.	80 59.6	79 59.0	272 40.7	352 39.7	360 11.6	7 31.9	....	+ 0 01.3	7 32.4	E.	Apr. 24, a.m.
24, p.m.	84 22.1	77 53.4	274 47.6	352 41.0	360 11.4	7 30.4	7 31.1	− 0 09.1	7 22.0	E.	24, a.m.
									7 27.2	E.	

MONROE, LA. $\phi = 32° 29'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Apr. 26, a.m.	75 46.7	82 37.2	75 03.5	352 26.3	220 39.3	228 13.0					
26, a.m.	72 04.6	84 52.2	77 19.7	352 27.5	220 39.7	228 12.2	228 12.6	+139 22.9	7 35.5	E.	Apr. 26, a.m.

JACKSON, MISS. $\phi = 32° 21'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Apr. 28, a.m.	81 15.0	78 30.8	71 45.5	353 14.7	226 42.6	233 27.9					
28, p.m.	80 12.0	78 58.8	73 34.1	352 32.9	226 01.3	233 28.4	233 28.1	133 52.4	7 20.5	E.	Apr. 28, a.m.

GOLCONDA, ILL. $\phi = 37° 23'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
June 15, a.m.	63 33.2	79 48.6	81 09.6	1 21.0	359 59.5	358 38.5	358 38.1	7 32.0	6 10.1	E.	June 15, a.m.
16, a.m.	69 19.6	75 47.4	77 09.6	1 22.2	360 00.0	358 37.8		7 29.2	6 07.3	E.	16, a.m.
17, a.m.	72 47.2	73 20.2	67 23.4	354 03.2	379 16.2	25 13.0	25 13.0	19 13.1	5 59.9	E.	17, a.m.
									6 05.8	E.	

SAINT LOUIS, MO. $\phi = 38° 38'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
June 24, p.m.	85 51.1	63 08.2	290 18.0	353 26.2	273 19.0	279 52.8	....	86 47.5	6 33.2	E.	June 24, p.m.
26, p.m.	79 00.3	68 49.2	284 45.9	353 35.1	273 14.5	279 39.4	....	86 48.4	6 34.1	E.	25, p.m.
26, p.m.	81 16.7	67 01.0	286 29.2	353 30.2	273 14.5	279 44.3	....	86 53.2	6 38.9	E.	26, a.m.
26, p.m.	84 42.5	64 11.8	289 19.5	353 31.3	273 14.5	279 43.2	....	86 49.3	6 35.0	E.	26, a.m.
July 4, p.m.	72 24.4	74 31.0	278 56.6	353 27.6	273 13.6	279 46.0	....	86 45.8	6 31.5	E.	26, p.m.
5, p.m.	73 50.4	73 34.6	279 54.3	353 28.9	273 14.5	279 45.6	....	86 49.8	6 35.5	E.	26, p.m.
5, p.m.	76 17.8	71 43.6	281 45.0	353 28.6	273 14.5	279 45.9	....	86 44.8	6 30.5	E.	July 2.
5, p.m.	78 44.9	69 50.2	283 32.5	353 22.7	273 14.5	279 51.8	....	86 54.2	6 39.9	E.	3, a.m.
5, p.m.	81 11.5	67 54.8	285 34.9	353 29.7	273 14.5	279 44.8	....	86 44.4	6 30.1	E.	4, p.m.
5, p.m.	83 18.5	66 12.0	287 18.6	353 30.6	273 14.5	279 43.9	....	86 48.2	6 33.9	E.	4, p.m.
9, a.m.	77 43.6	71 07.4	64 35.4	353 28.0	273 13.3	279 45.3	....	86 50.6	6 36.3	E.	4, p.m.
9, a.m.	75 03.5	73 09.4	66 37.0	353 27.6	273 13.3	279 45.7	279 45.7	86 53.1	6 38.8	E.	4, p.m.
								86 58.6	6 44.3	E.	5, a.m.
								86 47.5	6 33.2	E.	5, p.m.
								86 48.1	6 33.8	E.	5, p.m.
								86 51.4	6 37.1	E.	5, p.m.
								86 45.4	6 31.1	E.	6, p.m.
								86 46.5	6 32.2	E.	6, p.m.
								86 50.2	6 35.9	E.	6, p.m.
								86 53.8	6 39.5	E.	9, a.m.
									6 35.2	E.	

Observations for Declination—Continued.

SAINT LOUIS, MO. SECOND STATION.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
1872.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
July 12, a.m.	72 11.8	75 48.8	75 58.0	0 09.2	280 00.0	279 50.8	....	86 57.0	6 49.2	E.	July 12, a.m.
12, a.m.	70 08.1	77 20.4	77 26.8	0 06.4	280 00.0	279 53.6	279 52.2	86 56.5	6 48.7	E.	12, a.m.
									6 48.9	E.	

SAINT LOUIS, MO. THIRD STATION.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 3, a.m.	64 49.2	87 19.2	61 10.3	333 51.1	258 13.6	284 22.5	....	82 27.9	6 53.6	E.	Aug. 3, p.m.
4, a.m.	59 16.7	92 06.6	85 05.0	352 58.4	277 32.9	284 34.5	....	82 04.3	6 30.0	E.	3, p.m.
4, a.m.	54 49.8	95 53.0	89 03.8	353 10.8	277 32.9	284 22.1	....	82 22.9	6 48.6	E.	4, a.m.
5, a.m.	62 19.1	90 01.4	83 12.3	353 10.9	277 34.5	284 23.6	284 25.7	82 25.5	6 51.2	E.	4, a.m.
								82 09.0	6 34.7	E.	4, p.m.
								82 13.4	6 39.1	E.	4, p.m.
								82 23.3	6 49.0	E.	5, a.m.
								82 07.5	6 33.2	E.	5, p.m.
								82 13.0	6 38.7	E.	5, p.m.
								82 18.6	6 44.3	E.	6, a.m.
								82 03.2	6 28.9	E.	8, p.m.
								82 21.4	6 47.1	E.	9, a.m.
								82 07.0	6 32.7	E.	9, a.m.
								82 10.1	6 35.8	E.	9, p.m.
								82 14.4	6 40.1	E.	10, a.m.
								82 05.6	6 31.3	E.	10, p.m.
									6 39.9	E.	

DUBUQUE, IOWA. $\phi = 42° 30'$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 24, p.m.	79 14.9	83 22.4	269 18.2	352 40.6	350 36.8	357 56.2	357 56.2	9 36.4	7 32.6	E.	Aug. 24, p.m.
								9 28.4	7 24.6	E.	25, p.m.
								9 28.7	7 24.9	E.	25, p.m.
								9 32.0	7 28.2	E.	26, p.m.
								9 38.9	7 35.1	E.	26, p.m.
								9 47.4	7 43.6	E.	27, a.m.
								9 49.7	7 45.9	E.	27, a.m.
									7 33.6	E.	

WENONA, ILL. $\phi = 41° 05'$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 30, a.m.	60 19.0	105 15.2	98 55.0	353 39.8	338 01.0	344 21.2	....	21 46.2	6 07.6	E.	Aug. 29, p.m.
30, p.m.	81 22.4	86 02.0	267 37.7	353 39.7	338 00.0	344 20.3	....	21 45.6	6 07.0	E.	29, p.m.
31, a.m.	62 58.6	103 03.2	96 24.0	353 20.8	337 43.5	344 22.7	344 21.4	21 55.4	6 16.8	E.	30, a.m.
								21 39.8	6 01.2	E.	30, a.m.
								21 40.2	6 01.6	E.	30, p.m.
								21 39.4	6 00.8	E.	30, p.m.
								21 46.6	6 08.0	E.	30, p.m.
									6 06.1	E.	

MACON, ILL. $\phi = 39° 42'$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Sept. 1, a.m.	72 32.9	93 58.4	88 42.1	354 43.7	295 41.8	300 58.1	....	64 29.2	5 29.0	E.	Sept. 1, a.m.
1, p.m.	81 39.5	86 37.4	268 06.2	354 43.6	295 45.2	301 01.6	300 59.8	64 28.4	5 28.2	E.	1, a.m.
								64 23.6	5 23.4	E.	1, a.m.
								64 19.6	5 19.4	E.	1, a.m.
								64 17.0	5 16.8	E.	1, p.m.
								64 17.8	5 17.6	E.	1, p.m.
								64 19.6	5 19.4	E.	1, p.m.
								64 17.7	5 17.5	E.	1, p.m.
								64 22.0	5 21.8	E.	1, p.m.
									5 21.5	E.	1, p.m.

Observations for Declination—Continued.

HIGHLAND, ILL. $\phi=38° 45'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of ob'ns for declination.
1872.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
Sept. 2, p.m.	82 24.2	86 24.6	267 13.0	353 37.6	355 03.0	1 25.4	....	+5 05.3	6 30.7	E.	Sept. 2, p.m.
3, p.m.	84 40.1	85 04.4	275 08.7	360 13.1	1 38.5	1 25.4	1 25.4	5 10.0	6 35.4	E.	2, p.m.
								5 09.2	6 34.6	E.	2, p.m.
								5 08.1	6 33.5	E.	3, p.m.
								5 11.5	6 36.9	E.	4, a.m.
									6 34.2	E.	

HERMANN, MO. $\phi=38° 42'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of ob'ns for declination.
Sept. 29, a.m.	70 44.5	110 01.2	101 42.1	351 40.9	290 00.0	298 19.1	....	70 03.1	8 16.5	E.	Sept. 27, a.m.
29, p.m.	81 00.4	100 59.8	250 56.7	351 56.5	290 07.5	298 11.0	....	69 51.0	8 04.4	E.	29, p.m.
30, p.m.	77 01.1	104 58.6	254 58.8	359 57.4	298 10.7	298 13.3	....	70 04.2	8 17.6	E.	29, p.m.
30, p.m.	79 46.5	102 34.2	257.25.2	359 59.4	298 09.8	298 10.4	298 13.4	70 00.0	8 13.4	E.	30, p.m.
								70 03.9	8 17.3	E.	30, p.m.
									8 13.8	E.	

SEDALIA, MO. $\phi=38° 42'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of ob'ns for declination.
Oct. 2, a.m.	68 55.9	112.38.4	104 16.0	351 37.6	20 32.2	28 54.6	....	20 30.9	8 17.7	E.	Oct. 2, p.m.
2, a.m.	65 36.2	116 04.0	107 54.5	351 50.5	20 33.2	28 42.7	28 48.6	20 32.5	8 16.1	E.	3, a.m.
									8 16.9	E.	

KANSAS CITY, MO. $\phi=39° 05'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of ob'ns for declination.
Oct. 4, a.m.	68 47.5	115 09.3	115 19.0	0 09.7	290 03.0	289 53.3	289 53.3	80 42.0	10 35.3	E.	Oct. 3, p.m.
								80 51.2	10 44.5	E.	4, a.m.
								80 37.2	10 30.5	E.	4, p.m.
									10.36.8	E.	

MANHATTAN, KANS. $\phi=39° 12'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of ob'ns for declination.
Oct. 6, a.m.	71 00.3	114 07.4	103 10.7	349 03.3	331 54.5	342 51.2	....	28 05.0	10 55.2	E.	Oct. 6, a.m.
7, a.m.	64 36.2	122 03.0	122 05.8	0 02.8	342 52.8	342 50.0	....	28 05.0	10 55.2	E.	6, a.m.
7, p.m.	85 25.3	101 29.6	258 32.6	0 02.2	342 51.5	342 49.3	342 50.2	28 01.7	10 51.9	E.	6, p.m.
								28 06.1	10 56.3	E.	7, a.m.
								27 57.7	10 47.9	E.	7, m.
								27 54.8	10 45.0	E.	7, p.m.
								27 57.7	10 47.9	E.	7, p.m.
									10 51.3	E.	

SALINA, KANS. $\phi=39° 30'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of ob'ns for declination.
Oct. 9, a.m.	80 15.2	106 55.2	106 32.1	359 36.9	360 00.0	0 23.1	0 23.1	12 24.8	12 47.9	E.	Oct. 9, a.m.

ELLIS, KANS. $\phi=38° 56'.0$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of ob'ns for declination.
Oct. 9, p.m.	84 06.5	103 28.3	252 00.9	355 29.2	222 44.5	227 15.3	....	145 09.4	12 24.7	E.	Oct. 9, p.m.
10, a.m.	67 14.2	120 26.4	120 27.2	360 00.8	227 16.2	227 15.4	227 15.3	145 13.5	12 28.8	E.	10, a.m.
								145 05.9	12 21.2	E.	10, p.m.
									12 24.9	E.	

Observations for Declination—Continued.

WALLACE, KANS. $\phi=38° 55'.0$.

Date.	Corrected Z. D. ☉	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of ob'ns for declination.
1872.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
								13 25.3	13 25.3	E.	Oct. 11, a.m.
								13 17.5	13 17.5	E.	11, a.m.
								13 17.8	13 17.8	E.	11, p.m.
							*0 00.0	13 12.0	13 12.0	E.	11, p.m.
								13 15.2	13 15.2	E.	11, p.m.
								13 23.3	13 23.3	E.	12, a.m.
								13 14.0	13 14.0	E.	12, p.m.
									13 17.9	E.	

DENVER, COLO. $\phi=39° 45'$.

Oct. 13, a.m.	71 52.1	117 37.0	102 59.6	345 22.6	305 25.1	320 02.5	....	54 36.5	14 40.0	E.	Oct. 13, a.m.
13, p.m.	84 30.8	105 25.0	241 44.6	347 09.6	307 15.6	320 06.0	....	54 42.2	14 45.7	E.	13, a.m.
13, a.m.	67 21.1	123 34.7	123 38.6	360 03.9	320 02.8	319 58.9	....	54 42.7	14 46.2	E.	13, p.m.
19, p.m.	87 11.9	105 59.0	253 55.2	359 54.2	320 00.8	320 06.6	320 03.5	54 49.4	14 52.9	E.	14, a.m.
								54 37.0	14 40.5	E.	14, p.m.
								54 41.6	14 45.1	E.	14, p.m.
								54 41.3	14 44.8	E.	19, p.m.
								54 39.1	14 42.6	E.	19, p.m.
									14 44.7	E.	

PUEBLO, COLO. $\phi=38° 12'$.

Oct. 16, a.m.	75 03.2	114 48.6	100 52.4	346 03.8	307 00.5	320 56.7	....	52 58.7	13 56.4	E.	Oct. 15, p.m.
16, a.m.	69 03.4	121 11.8	107 18.6	346 06.8	307 01.8	320 55.0	....	52 56.8	13 54.5	E.	16, a.m.
16, p.m.	84 00.4	106 48.8	239 09.8	345 58.6	307 00.0	321 01.4	320 57.7	52 58.0	13 55.7	E.	16, p.m.
								52 57.8	13 55.5	E.	16, p.m.
									13 55.5	E.	

CHEYENNE, WYO. $\phi=41° 05'$.

								15 21.8	15 21.8	E.	Oct. 21, p.m.
								15 24.4	15 24.4	E.	21, p.m.
								15 33.6	15 33.6	E.	22, a.m.
							†0 00.0	15 28.6	15 28.6	E.	22, p.m.
								15 24.5	15 24.5	E.	22, p.m.
								15 27.5	15 27.5	E.	23, p.m.
									15 26.7	E.	

SYDNEY, NEBR. $\phi=41° 08'$.

								152 32.5	14 35.0	E.	Oct. 25, p.m.
								152 29.0	14 38.5	E.	25, p.m.
								152 33.0	14 34.5	E.	25, p.m.
							‡167 07.5	152 31.0	14 36.5	E.	25, p.m.
								152 31.0	14 36.5	E.	25, p.m.
								152 30.5	14 37.0	E.	25, p.m.
								152 27.5	14 40.0	E.	25, p.m.
									14 36.9	E.	

NORTH PLATTE, NEBR. $\phi=41° 11'$.

Oct. 26, p.m.	85 17.4	111 36.2	235 33.0	347 09.2	355 05.4	7 56.2	7 56.2	+5 17.8	13 14.0	E.	Oct. 26, a.m.
								5 09.2	13 05.4	E.	26, p.m.
								5 08.1	13 04.3	E.	26, p.m.
								5 10.0	13 06.2	E.	26, p.m.
									13 07.5	E.	

*In meridian of boundary observatory. †Astronomical meridian of Wheeler Survey. ‡Astronomical azimuth of Wheeler Survey.

Observations for Declination—Continued.

GRAND ISLAND, NEBR. $\phi = 40° 55'$.

Date.	Corrected Z. D. ⊙	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date ob'ns for declination.
1871.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
Oct. 27, p.m.	82 08.5	115 03.3	231 45.1	346 48.4	48 00.0	61 11.6	…………	47 56.0	13 15.9	E.	Oct. 27, a.m.
27, p.m.	84 34.3	112 37.4	234 10.3	346 47.7	48 00.0	61 12.3	61 11.9	48 00.0	13 11.9	E.	27, m.
								48 00.2	13 11.7	E.	27, p.m.
								47 57.5	13 14.4	E.	27, p.m.
									13 13.5	E.	

OMAHA, NEBR. $\phi = 41° 16'.0$.

Date.	Corrected Z. D. ⊙	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date ob'ns for declination.
Oct. 31, a.m.	77 43.1	121 54.0	111 32.8	349 38.8	348 07.9	358 29.1	…………	12 19.1	10 48.0	E.	Oct. 31, a.m.
31, a.m.	73 07.0	127 39.3	117 18.4	349 39.1	348 07.9	358 28.8	358 28.9	12 14.1	10 43.0	E.	31, m.
								12 13.4	10 42.3	E.	31, p.m.
								12 14.7	10 43.6	E.	31, p.m.
									10 44.2	E.	

DES MOINES, IOWA. $\phi = 41° 35'$.

Date.	Corrected Z. D. ⊙	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date ob'ns for declination.
Nov. 1, p.m.	87 36.7	112 12.8	243 16.2	355 29.0	344 59.1	349 30.1	…………	20 16.5	9 44.8	E.	Nov. 1, p.m.
6, a.m.	74 34.5	129 11.0	124 40.4	355 29.4	344 58.5	349 29.1	…………	20 20.7	9 49.0	E.	2, a.m.
6, a.m.	69 10.4	137 27.6	133 03.3	355 35.7	345 01.5	349 25.8	349 28.3	20 20.8	9 49.1	E.	5, p.m.
								20 25.4	9 53.7	E.	6, a.m.
								20 19.1	9 47.4	E.	6, p.m.
									9 48.8	E.	

1871–'72.

OBSERVATIONS FOR DIP.

STATIONS.

Golconda, Ill.
Richmond, Ind.
New Albany, Ind.
Edgefield, Tenn.
Corinth, Miss.
Oxford, Miss.
Grenada, Miss.
Magnolia Base, La.
New Orleans, La.
S. W. Pass, La.
Osgood's Island, La.
Avery's Island, La.
Brashear City, La.
Baton Rouge, La.
Grand Ecore, La.
Shreveport, La.
Longview, Tex.
Alexandria, La.
Natchez, Miss.
Vicksburg, Miss.
Memphis, Tenn.
Cairo, Ill.
Saint Louis, Mo.
Dubuque, Iowa.
Wenona, Ill.
Macon, Ill.
Highland, Ill.
Hermann, Mo.
Sedalia, Mo.
Kansas City, Mo.
Manhattan, Kans.
Ellis, Kans.
Wallace, Kans.
Denver, Colo.
Pueblo, Colo.
Cheyenne, Wyo.
Sydney, Nebr.
North Platte, Nebr.
Grand Island, Nebr.
Omaha, Nebr.
Des Moines, Iowa.

Observer, T. C. HILGARD.

OBSERVATIONS FOR DIP.

MAGNETIC SURVEY, 1871-'72.

GOLCONDA, ILL.

Date.	Needle.	Polarity north.			Polarity south.			Dip.
		Circle E.	W.	Mean.	Circle E.	W.	Mean.	
1871.		° ′	′	′	° ′	′	′	° ′
Aug. 31	1	67 57.5	88.5	73.0	67 74.0	55.5	64.7	68 08.8
31	2	67 54.0	60.0	57.0	67 80.0	65.0	72.5	68 04.8
Sept. 1	1	67 41.0	80.5	60.7	68 07.0	09.0	08.0	68 04.3
1	2	67 44.0	56.0	50.0	67 51.5	51.5	51.5	67 50.7
12	1	68 08.0	16.5	12.2	67 49.0	106.5	77.7	68 14.9
12	2	67 53.0	54.0	53.5	68 17.5	15.0	16.2	68 04.8
18	1	67 53.0	72.0	62.5	67 42.0	57.5	49.7	67 56.1
18	2	67 41.0	58.0	49.5	68 05.5	34.5	20.0	68 04.7
20	1	67 58.0	80.0	69.0	67 45.0	75.5	60.2	68 04.6
20	2	67 43.5	63.0	53.2	68 01.0	28.0	14.5	68 03.7
22	1	68 09.0	32.5	20.7	67 43.5	77.0	60.2	68 10.4
22	2	67 37.0	87.0	62.0	68 03.0	08.5	05.7	68 03.8
Oct. 3	1	67 58.0	76.0	67.0	67 51.0	57.0	54.0	68 00.5
3	2	67 46.0	61.5	53.7	67 45.0	73.0	59.0	67 56.3
13	1	68 07.5	09.0	08.2	67 44.0	64.5	54.2	68 01.2
13	2	67 40.0	59.5	49.7	67 55.5	82.5	69.0	67 59.3
								68 03.1
1872.								
June 5	1	67 50.5	72.0	61.2	67 38.5	58.5	48.5	67 54.8
5	2	67 41.0	69.5	55.2	67 39.0	79.0	59.0	67 57.1
								67 55.9

RICHMOND, IND.

1871.								
Nov. 22, p. m.	1	71 30.0	50.0	40.0	71 15.5	43.0	29.2	71 34.6
22, p. m.	2	71 16.5	32.0	24.2	71 31.0	41.0	36.0	71 30.1
23, m.	1	71 25.5	34.0	29.7	71 08.5	33.5	21.0	71 25.3
23, m.	2	71 01.5	20.0	10.7	71 18.0	26.0	22.0	71 16.3
								71 26.6

NEW ALBANY, IND.

Nov. 28	1	70 15.0	44.5	29.7	70 28.5	04.5	16.5	70 23.1
28	2	70 11.5	09.0	10.2	70 28.5	34.0	31.2	70 20.6
								70 21.9

EDGEFIELD, TENN.

Dec. 2, m.	1	67 11.5	23.5	17.5	67 00.5	15.0	07.7	67 12.6
2, m.	2	66 53.0	83.0	68.0	66 49.0	90.0	69.5	67 08.8
								67 10.7

CORINTH, MISS.

Dec. 3, m.	1	65 48.0	75.0	61.5	65 27.0	60.0	43.5	65 52.5
3, m.	2	65 42.5	72.5	57.5	65 44.0	68.0	56.0	65 56.7
								65 54.6

Observations for Dip—Continued.

OXFORD, MISS.

Date.	Needle.	Polarity north.			Polarity south.			Dip.
		Circle E.	W.	Mean.	Circle E.	W.	Mean.	
1871.		° ′	′	′	° ′	′	′	° ′
Dec. 13	1	65 05.0	60.5	32.7	64 49.5	64.0	56.7	65 14.7
13	2	64 49.0	58.5	53.7	64 42.5	83.5	63.0	64 58.4
24	1	65 07.0	13.5	10.2	64 41.0	62.5	51.7	65 00.9
24	2	64 38.5	64.0	51.2	64 67.5	69.0	68.2	64 59.7
								65 03.4
1872.								
May 20, a. m.	1	65 21.5	29.0	25.2	64 48.0	64.0	56.0	65 10.6
20, a. m.	2	64 40.0	67.5	53.7	64 61.0	71.0	66.0	64 59.9
								65 05.3

GRENADA, MISS.

Jan. 11	1	64 19.0	41.0	30.0	64 10.5	43.5	27.0	64 28.5
11	2	64 07.5	23.0	15.2	64 16.0	32.0	24.0	64 19.6
								64 24.0

MAGNOLIA BASE, LA.

Jan. 17	1	59 23.0	24.0	23.5	59 07.0	37.0	22.0	59 22.7
17	2	59 22.0	02.5	12.2	59 38.0	35.0	36.5	59 24.3
								59 23.5

CITY PARK, NEW ORLEANS, LA.

Feb. 12	1	59 47.5	48.5	48.0	59 32.0	53.5	42.7	59 45.3
12	2	59 39.5	33.0	36.2	59 35.0	59.5	47.2	59 41.7
								59 43.5

FAIR GROUNDS, NEW ORLEANS, LA.

Feb. 15	1	59 40.5	80.0	60.2	59 31.5	58.5	45.0	59 52.6
15	2	59 22.5	48.0	35.2	59 45.0	63.5	54.2	59 44.7
								59 48.6

SOUTHWEST PASS, LA., STATION No. 1.

Mar. 2	1	58 31.5	75.5	53.5	58 33.0	44.0	38.5	58 46.0
2	2	58 09.5	44.5	27.0	58 72.5	62.0	67.2	58 47.1
								58 46.5

SOUTHWEST PASS, LA., STATION No. 2.

Mar. 3	1	58 44.0	63.0	53.5	58 29.0	39.5	34.2	58 43.8
3	2	58 21.5	62.5	42.0	58 50.0	72.0	61.0	58 51.5
								58 47.6

OSGOOD'S ISLAND, LA.

Mar. 5	1	59 05.0	19.5	12.2	58 38.5	63.0	50.7	59 01.4
5	2	58 43.0	58.0	50.5	59 04.5	18.5	11.5	59 01.0
								59 01.2

Observations for Dip—Continued.

AVERY'S ISLAND, LA.

Date.	Needle.	Polarity north.			Polarity south.			Dip.
		Circle E.	W.	Mean.	Circle E.	W.	Mean.	
1872.		° ′	′	′	° ′	′	′	° ′
Mar. 15	1	59 24.0	47.0	35.5	59 04.5	29.0	16.8	59 26.1
15	2	59 02.0	24.0	13.0	59 43.5	37.5	40.5	59 26.7
								59 26.4

BRASHEAR CITY, LA.

Mar. 23	1	59 12.0	38.5	25.2	58 53.5	76.0	64.7	59 14.9
23	2	58 46.0	82.0	64.0	59 22.5	40.0	31.7	59 17.8
								59 16.3

BATON ROUGE, LA.

Apr. 1	1	60 23.5	19.0	21.2	60 05.5	30.5	18.0	60 19.6
1	2	59 56.5	77.5	67.0	60 25.5	42.5	34.0	60 20.5
								60 20.0

GRAND ECORE, LA.

Apr. 10	1	61 34.5	40.5	37.5	61 04.5	28.5	16.5	61 27.0
10	2	61 10.0	21.5	15.7	61 37.5	41.0	39.2	61 27.4
								61 27.2

SHREVEPORT, LA.

Apr. 14	1	62 01.0	32.5	16.7	61 40.5	62.0	51.3	62 04.0
14	2	61 50.0	72.0	61.0	61 40.5	97.0	68.7	62 04.8
								62 04.4

LONGVIEW, TEX.

Apr. 15	1	61 50.0	72.0	61.0	61 35.5	65.0	50.2	61 55.6
15	2	61 44.5	59.0	51.7	61 62.0	73.0	67.5	61 59.6
								61 57.6

ALEXANDRIA, LA.

Apr. 17	1	60 54.5	67.5	61.0	60 21.0	66.5	43.7	60 52.3
17	2	60 40.0	52.0	46.0	60 57.5	65.0	61.2	60 53.6
								60 53.0

NATCHEZ, MISS.

Apr. 22	1	61 29.0	41.5	35.2	61 10.5	36.0	23.2	61 29.2
22	2	61 11.5	31.0	21.2	61 13.5	41.0	27.2	61 24.2
								61 26.7

VICKSBURG, MISS.

Apr. 24	1	62 21.0	43.5	32.2	62 07.5	38.0	22.7	62 27.4
24	2	62 14.5	32.5	23.5	62 31.0	39.5	35.2	62 29.3
								62 28.4

Observations for Dip—Continued.

MEMPHIS, TENN.

Date.	Needle.	Polarity north. Circle E.	Polarity north. W.	Polarity north. Mean.	Polarity south. Circle E.	Polarity south. W.	Polarity south. Mean.	Dip.
1872.		° ′	′	′	° ′	′	′	° ′
May 21	1	65 33.5	67.0	50.2	65 19.0	29.5	24.2	65 37.2
21	2	64 95.5	59.5	77.5	65 60.5	55.5	58.0	65 37.7
								65 37.5

CAIRO, ILL.

Date.	Needle.	Polarity north. Circle E.	Polarity north. W.	Polarity north. Mean.	Polarity south. Circle E.	Polarity south. W.	Polarity south. Mean.	Dip.
June 21	1	67 36.0	49.5	42.7	67 28.0	48.0	38.0	67 40.3
21	2	67 40.5	50.5	45.5	67 38.5	39.5	39.0	67 42.2
								67 41.3

SAINT LOUIS, MO., STATION ON COMPTON'S HILL.

Date.	Needle.	Polarity north. Circle E.	Polarity north. W.	Polarity north. Mean.	Polarity south. Circle E.	Polarity south. W.	Polarity south. Mean.	Dip.
June 25	1	69 29.0	48.0	38.5	69 19.0	34.5	26.7	69 32.6
25	2	69 18.0	41.5	29.7	69 43.5	36.0	39.7	69 34.7
July 6	1	69 35.5	43.0	39.2	69 41.0	30.0	35.5	69 37.3
6	2	69 15.5	51.5	33.5	69 18.5	47.0	32.7	69 33.1
								69 34.4

DUBUQUE, IOWA.

Date.	Needle.	Polarity north. Circle E.	Polarity north. W.	Polarity north. Mean.	Polarity south. Circle E.	Polarity south. W.	Polarity south. Mean.	Dip.
Aug. 24	1	73 04.0	17.5	10.7	72 55.0	66.0	60.5	73 05.6
24	2	73 00.0	17.0	08.5	72 44.5	90.5	67.5	73 08.0
								73 06.8

WENONA, ILL.

Date.	Needle.	Polarity north. Circle E.	Polarity north. W.	Polarity north. Mean.	Polarity south. Circle E.	Polarity south. W.	Polarity south. Mean.	Dip.
Aug. 30	1	71 25.0	66.5	45.7	71 39.0	56.5	47.7	71 46.7
30	2	71 45.0	37.0	41.0	71 24.5	58.0	41.2	71 41.1
								71 43.9

MACON, ILL.

Date.	Needle.	Polarity north. Circle E.	Polarity north. W.	Polarity north. Mean.	Polarity south. Circle E.	Polarity south. W.	Polarity south. Mean.	Dip.
Sept. 1	1	70 04.5	08.0	06.2	70 05.0	18.0	11.5	70 08.8
1	2	70 02.0	24.5	13.2	70 14.5	32.0	23.2	70 18.2
								70 13.5

HIGHLAND, ILL.

Date.	Needle.	Polarity north. Circle E.	Polarity north. W.	Polarity north. Mean.	Polarity south. Circle E.	Polarity south. W.	Polarity south. Mean.	Dip.
Sept. 2	1	69 39.5	62.0	50.7	69 35.5	54.0	44.7	69 47.7
2	2	69 45.5	41.0	43.2	69 39.0	61.5	50.2	69 46.7
								69 47.2

HERMANN, MO.

Date.	Needle.	Polarity north. Circle E.	Polarity north. W.	Polarity north. Mean.	Polarity south. Circle E.	Polarity south. W.	Polarity south. Mean.	Dip.
Sept. 27	1	69 00.0	50.5	25.2	69 13.0	27.5	20.2	69 22.7
27	2	69 09.6	23.5	16.2	69 20.0	27.5	23.7	69 19.9
								69 21.3

SEDALIA, MO.

Date.	Needle.	Polarity north. Circle E.	Polarity north. W.	Polarity north. Mean.	Polarity south. Circle E.	Polarity south. W.	Polarity south. Mean.	Dip.
Oct. 2	1	68 40.5	69.5	55.0	68 37.0	50.5	43.7	68 49.3
2	2	68 44.0	42.5	43.2	68 54.0	51.0	52.5	68 47.7
								68 48.5

Observations for Dip—Continued.

KANSAS CITY, MO.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
1872.		° ′	′	′	° ′	′	′	° ′
Oct. 4	1	68 54.5	90.0	72.2	68 58.0	69.0	63.5	69 07.8
4	2	68 55.5	68.5	62.0	68 49.0	78.5	63.7	69 02.8
								69 05.3

MANHATTAN, KANS.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Oct. 6	1	68 43.0	79.5	61.2	68 29.0	62.5	45.7	68 53.4
6	2	68 34.0	49.5	41.7	68 37.0	63.5	50.2	68 45.9
7	1	68 32.5	63.5	48.0	68 36.5	50.5	43.5	68 45.7
7	2	68 29.0	47.5	38.2	68 37.5	62.0	49.7	68 44.0
								68 47.2

ELLIS, KANS.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Oct. 10	1	67 47.5	85.0	66.2	67 28.0	85.2	56.7	68 01.4
10	2	67 29.0	37.0	33.0	67 46.0	56.0	51.0	67 42 0
								67 51.7

WALLACE, KANS.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Oct. 12	1	66 22.0	174.0	98.0	66 58.0	114.0	86.0	67 32.0
12	2	67 06.5	34.0	20.2	67 30.5	54.0	42.2	67 31.2
								67 31.6

DENVER, COLO.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Oct. 14	1	67 01.0	63.5	32.2	67 07.5	82.5	45.0	67 38.6
14	2	67 07.5	43.5	25.5	67 07.0	63.0	35.0	67 30.2
								67 34.4

PUEBLO, COLO.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Oct. 16	1	66 43.5	74.0	58.7	66 08.0	39.5	23.7	66 41.2
16	2	66 23.5	63.0	43.2	66 09.5	46.0	27.7	66 35.4
								66 38.3

CHEYENNE, WYO.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Oct. 22	1	68 49.0	63.0	56.0	68 42.5	75.0	58.7	68 57.3
22	2	68 36.0	98.0	67.0	68 32.0	69.5	50.8	68 58.9
								68 58.1

SYDNEY, NEBR.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Oct. 25	1	68 57.5	120.5	89.0	68 34.5	122.5	78.5	69 23.7
25	2	68 59.0	104.0	81.5	68 40.0	133.0	86.5	69 24.0
								69 23.9

NORTH PLATTE, NEBR.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Oct. 26	1	69 18.5	50.5	34.5	69 07.5	56.0	31.7	69 33.1
26	2	69 42.5	88.0	65.2	69 00.5	65.5	33.0	69 49.1
								69 41.1

Observations for Dip—Continued.

GRAND ISLAND, NEBR.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
1872.		° ′	′	′	° ′	′	′	° ′
Oct. 27	1	69 49.0	117.5	83.2	70 07.0	38.5	22.7	70 23.0
27	2	69 58.0	92.5	75.2	69 33.0	89.0	61.0	70 08.1
								70 15.5

OMAHA, NEBR.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Oct. 31	1	70 27.5	114.0	70.7	70 90.5	39.5	65.0	71 07.8
31	2	70 42.0	85.5	63.7	70 97.0	33.5	65.2	71 04.4
								71 06.1

DES MOINES, IOWA.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Nov. 2	1	71 09.5	59.0	34.2	71 03.0	56.0	29.5	71 31.8
2	2	71 01.5	50.5	26.0	70 54.5	129.5	92.0	71 29.0
								71 30.4

1871–'72.

OBSERVATIONS FOR INTENSITY.

STATIONS.

New Albany, Ind.
Edgefield, Tenn.
Corinth, Miss.
Oxford, Miss.
Grenada, Miss.
Magnolia Base, La.
New Orleans, La.
Southwest Pass, La.
Osgood's Island, La.
Avery's Island, La.
Brashear City, La.
Baton Rouge, La.
Grand Ecore, La.
Shreveport, La.
Longview, Tex.
Alexandria, La.
Natchez, Miss.
Vicksburg, Miss.
Monroe, La.
Jackson, Miss.
Memphis, Tenn.
Golconda, Ill.
Cairo, Ill.
Saint Louis, Mo.
Dubuque, Iowa.
Wenona, Ill.
Macon, Ill.
Highland, Ill.
Hermann, Mo.
Sedalia, Mo.
Kansas City, Mo.
Manhattan, Kans.
Ellis, Kans.
Wallace, Kans.
Denver, Colo.
Pueblo, Colo.
Cheyenne, Wyo.
Sydney, Nebr.
North Platte, Nebr.
Grand Island, Nebr.
Omaha, Nebr.
Des Moines, Iowa.

Observer, T. C. HILGARD.

In the reduction of the observations for intensity in 1871–'72 the absolute horizontal force is obtained by comparison with Washington in the following manner:

By observations at Washington, August 11, 1871, the magnet made 120 vibrations in 466^s.59 at a temperature of 60° F. Further observations on March 25, 1873, give the time of 120 vibrations equal to 470^s.37 for the same magnet, temperature, and locality. From observations made by C. A. Schott, Assistant, Coast Survey, the absolute horizontal force at Washington was found to be 4.356 for the former date and 4.352 for the latter. By interpolation we form the table given on page 5. The horizontal intensity, or absolute horizontal force, H, is found for any station by the formula

$$H_1 = \frac{T^2 H}{T_1^2}$$

The table gives the logarithms of T^2H for the several dates.

The temperature correction to be applied to the observed time of 120 vibrations is derived as follows:

In Schott's garden, Washington, D. C.,

I. March 25, 1873.—Mean of two observations $T=468^s.6155$; $t=37^\circ.35$ F.

II. March 30, 1873.—Mean of two observations $T=471^s.4685$; $t=74^\circ.50$ F.

At that time the horizontal intensity was decreasing, consequently the time of 120 vibrations was increasing, the rate of increase being $0^s.00646$ per day. Referring I to the date of II, we have the following data for March 30:

$$T=\overset{s.}{468.6478};\quad t=\overset{\circ}{37.35}\text{ F.}$$
$$T=471.4685;\quad t=74.50\text{ F.}$$
$$\Delta T=\ \ 2.8207;\quad \Delta t=37.15\text{ F.}$$

The difference ΔT being a function of T^2 and of Δt, we assume

$$\Delta T=\rho\,\Delta t T^2,$$

or,

$$\rho=\frac{\Delta T}{\Delta t\,T^2}=0.00000034372$$

$$\therefore$$

$$\Delta T=0.00000034372T^2,\ \Delta t \text{ being }=1^\circ\text{ F.}$$

By this formula the following table was computed.

The correction is $=\Delta T(t-60^\circ\text{ F})$:

Observed time of 120 vibrations.	Correction for 1° F.	Observed time of 120 vibrations.	Correction for 1° F.
s.	s.	s.	s.
390	0. 0523	450	0. 0695
395	. 0539	455	. 0712
400	. 0553	460	. 0729
405	. 0568	465	. 0746
410	. 0582	470	. 0761
415	. 0597	475	. 0778
420	. 0612	480	. 0794
425	. 0627	485	. 0810
430	. 0640	490	. 0826
435	. 0654	495	. 0842
440	. 0669	500	. 0859
445	0. 0682	505	0. 0875

OBSERVATIONS FOR INTENSITY.

WASHINGTON, D. C.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Temp. corr'n to reduce to 60° F.	Time of 120 vibrations corrected.	Horizontal intensity.
1871.						
Aug. 11	9 26	84. 75	468. 245	— 1. 885	466. 360	
11	9 38	83. 50	468. 034	1. 789	466. 245	
12	11 33	79. 50	468. 120	1. 485	466. 635	
12	11 53	82. 25	468. 660	1. 694	466. 966	
12	12. 10	85. 00	468. 636	1. 904	466. 732	
					466. 588	4. 356
1873.						
Mar. 25	9 48	38. 00	468. 492	+ 1. 765	470. 257	
25	10 10	36. 70	468. 739	+ 1. 774	470. 513	
30	1 32	74. 20	471. 598	— 1. 097	470. 501	
30	2 28	74. 80	471. 339	— 1. 144	470. 195	
					470. 366	4. 352

Observations for Intensity—Continued.

Time of 120 vibrations, etc., in the middle of the respective months in Washington.

[For one day interpolate $\Delta T_w = 0.0064596$.]

Month and year.	T_w.	H_w.	Log $H_w T_w^2$.
1871.			
August	466.6069	4.356	5.9769959
September	466.8007	4.356	5.9773495
October	466.9945	4.356	5.9777031
November	467.1883	4.356	5.9780567
December	467.3821	4.355	5.9783322
1872.			
January	467.5759	4.355	5.9786924
February	467.7697	4.355	5.9790530
March	467.9635	4.355	5.9794134
April	468.1573	4.355	5.9797738
May	468.3511	4.354	5.9800312
June	468.5449	4.354	5.9803910
July	468.7387	4.354	5.9807504
August	468.9325	4.354	5.9811100
September	469.1263	4.354	5.9814696
October	469.3201	4.353	5.9817269
November	469.5139	4.353	5.9820857
December	469.7077	4.353	5.9824445
1873.			
January	469.9015	4.353	5.9828033
February	470.0953	4.353	5.9831621
March	470.2891	4.352	5.9834183

NEW ALBANY, IND.

Date	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n (reduction to 60° F.).	Time of 120 vibrations. At ——.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1871.	h. m.	°	s.	s.	s.	s.	
Nov. 28	1 02	38.0	459.75	+1.62	461.37		
28	1 28	36.0	459.73	+1.77	461.50	467.27	
					461.43	....	4.466

EDGEFIELD, TENN.

Dec. 1	2 56	52.0	461.08	+0.59	461.67		
1	3 15	47.0	459.07	+0.95	460.02	467.28	
					460.85	....	4.478

CORINTH, MISS.

Dec. 3	10 12	38.0	423.91	+1.37	525.28		
3	10 39	36.0	424.46	+1.50	425.96		
3	10 58	37.0	424.49	+1.44	425.93	467.31	
3	11 15	38.0	424.34	+1.37	425.71		
					425.72	....	5.248

Observations for Intensity—Continued.

OXFORD, MISS.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n (reduction to 60° F.).	Time of 120 vibrations. At ——.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1871–'72.	h. m.	°	s.	s.	s.	s.	
Dec. 12	4 32	58.1	418.58	+0.12	418.70		
25	12 04	75.0	419.39	−0.91	418.48		
25	12 25	75.0	419.38	−0.91	418.47	467.45	
Jan. 5	12 58	61.5	418.68	−0.09	418.59		
Dec. 26	....	....	....	....	418.56	....	5.444
1872.							
May 3	11 47	81.7	421.00	−1.34	419.66		
3	12 16	81.7	420.91	−1.34	419.57		
3	1 06	84.7	421.18	−1.52	419.66		
3	1 33	90.7	421.54	−1.89	419.65		
3	2 01	86.7	421.68	−1.64	419.78		
4	10 47	90.7	421.67	−1.89	420.04		
4	11 15	94.3	422.55	−2.12	420.43		
4	11 30	94.5	422.27	−2.13	420.14	468.28	
7	6 19	83.0	421.79	−1.41	420.38		
8	8 28	84.0	422.32	−1.48	420.84		
8	8 37	83.4	421.83	−1.45	420.38		
9	5 29	89.0	421.32	−1.79	419.53		
5	....	....	....	....	420.00	....	5.408

GRENADA, MISS.

Jan. 11	2 38	80.0	417.06	−1.21	415.85		
11	3 14	84.0	417.71	−1.46	416.25		
11	3 35	84.0	417.69	−1.46	416.23		
April 29	4 16	90.6	418.71	−1.86	416.85		
29	4 42	89.2	418.50	−1.78	416.72	468.02	
29	5 27	89 0	418.17	−1.76	416.41		
30	6 47	89.0	417.15	−1.75	415.40		
30	7 51	85.3	417.32	−1.51	415.81		
30	8 06	86.5	416.67	−1.60	415.07		
Mar. 23	....	....	....	....	416.07	....	5.510

MAGNOLIA BASE, LA.

Jan. 17	3 18	60.0	437.26	0.00	437.26		
17	3 40	60.0	437.29	0.00	437.29	467,59	
17	4 01	60.0	437.58	0.00	437.58		
					437.38	....	4.977

NEW ORLEANS, LA.

Feb. 10	3 23	81.0	401.75	−1.18	400.57		
10	3 33	82.0	401.80	−1.24	400.56		
15	12 07	74.0	400.23	−0.78	399.45	467.75	
15	12 47	75.0	400.00	−0.83	399.17		
15	2 45	76.6	400.49	−0.92	399.57		
					399.86	....	5.959

SOUTHWEST PASS, LA., STATION No. 1.

Mar. 2	2 57	71.5	392.44	−0.61	391.83	467.88	6.209

Observations for Intensity—Continued.

SOUTHWEST PASS, LA., STATION NO. 2.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n (reduction to 60° F.).	Time of 120 vibrations. At ——.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1872.	h. m.	°	s.	s.	s.	s.	
Mar. 3	9 43	85.0	392.39	−1.34	391.05		
3	10 06	67.8	391.50	−0.42	391.08	467.88	
3	10 21	61.8	391.17	−0.10	391.07		
					391.07	....	6.234

OSGOOD'S ISLAND, LA.

Mar. 5	7 48	75.0	397.38	−0.82	396.56		
5	8 04	74.8	397.04	−0.81	396.23	467.90	
					396.40	....	6.068

AVERY'S ISLAND, LA.

Mar. 16	4 13	78.7	399.40	−1.03	398.37		
16	4 36	78.5	399.22	−1.02	398.20	467.97	
					398.28	....	6.012

BRASHEAR CITY, LA.

Mar. 23	1 24	77.0	397.51	−0.93	396.58		
23	1 42	81.0	397.76	−1.15	396.61		
23	4 08	83.0	396.04	−1.25	394.79	468.01	
23	4 29	86.0	396.17	−1.42	394.75		
					395.68	....	6.093

BATON ROUGE, LA.

April 1	12 25	86.5	399.93	−1.47	398.46		
1	12 47	86.2	399.82	−1.45	398.37	468.06	
1	1 08	87.3	400.13	−1.52	398.61		
					398.48	....	6.008

GRAND ECORE, LA.

April 10	8 31	69.5	402.76	−0.54	402.22		
10	8 51	72.8	403.29	−0.72	402.57		
10	9 38	77.0	402.93	−0.96	401.97	468.13	
10	10 35	83.0	403.21	−1.30	401.91		
					402.17	....	5.901

SHREVEPORT, LA.

April 14	5 11	92.4	407.71	−1.87	405.84		
14	5 41	85.8	406.35	−1.48	404.87	468.15	
					405.35	....	5.809

LONGVIEW, TEX.

April 15	3 38	84.7	404.96	−1.42	405.54		
15	4 04	87.0	407.58	−1.56	406.02		
15	4 28	86.2	407.83	−1.51	406.32	468.16	
15	4 47	87.2	407.71	−1.57	406.14		
					406.00	....	5.790

Observations for Intensity—Continued.

ALEXANDRIA, LA.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n (reduction to 60° F.).	Time of 120 vibrations. At ——.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1872.	h. m.	°	s.	s.	s.	s.	
April 17	4 31	79.6	401.03	—1.10	399.93		
17	5 00	77.5	400.55	—0.98	399.57		
17	5 06	85.3	402.02	—1.42	400.60	468.17	
					400.03	....	5.965

NATCHEZ, MISS.

April 22	4 31	73.9	404.00	—0.79	403.21		
22	5 07	73.0	404.25	—0.74	403.51		
22	5 33	72.0	403.31	—0.68	402.63	468.20	
					403.12	....	5.874

VICKSBURG, MISS.

April 24	12 29	84.7	409.26	—1.44	407.82		
24	12 27	86.0	409.47	—1.51	407.96		
24	1 08	87.0	409.33	—1.57	407.76		
24	1 28	93.5	409.61	—1.96	407.65	468.22	
27	7 39	85.0	408.58	—1.45	407.13		
27	8 03	82.3	408.03	—1.29	406.74		
					407.51	....	5.749

MONROE, LA.

April 26	7 56	84.8	408.00	—1.44	406.56		
26	8 14	85.5	407.87	—1.48	406.39	469.23	
					406.48	....	5.778

JACKSON, MISS.

April 28	7 08	79.3	411.62	—1.14	410.48		
28	7 37	84.1	411.72	—1.42	410.30		
28	7 58	79.3	411.90	—1.14	410.76	468.24	
					410.51	....	5.665

MEMPHIS, TENN.

May 21	8 17	86.7	426.35	—1.68	424.67		
21	8 33	88.7	426.53	—1.81	424.72	468.39	
					424.70	....	5.296

GOLCONDA, ILL.

June 6	9 36	90.0	443.36	—2.05	441.31		
6	9 58	89.2	444.33	—2.00	442.33		
6	10 20	85.7	443.53	—1.76	441.77		
6	10 41	87.3	444.03	—1.88	442.15		
6	11 42	91.5	444.06	—2.15	441.91	468.53	
15	8 23	90.6	445.41	—2.10	443.31		
15	8 49	94.1	445.76	—2.36	443.40		
					442.31	....	4.885

Observations for Intensity—Continued.

CAIRO, ILL.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n (reduction to 60° F.).	Time of 120 vibrations. At —— .	Time of 120 vibrations. At Washington.	Horizontal intensity.
1872.	h. m.	°	s.	s.	s.	s.	
June 21	7 33	83.5	442.55	—1.61	440.94		
22	7 52	83.9	442.85	—1.64	441.21	468.58	
					441.08	....	4.914

SAINT LOUIS, MO.

June 26	9 28	94.3	458.46	—2.49	455.97		
26	10 00	95.0	458.60	—2.56	456.04		
26	10 23	95.7	458.73	—2.61	456.12		
July 6	4 22	98.7	458.89	—2.63	456.26		
6	4 43	93.5	457.42	—2.43	454.99	468.64	
6	5 01	90.2	457.42	—2.19	455.23		
6	5 30	90.8	456.93	—2.24	454.69		
					455.61	....	4.607
Nov. 23	3 49	57.4	453.47	+0.19	453.66		
24	12 07	61.5	454.22	—0.11	454.11		
24	2 15	63.0	454.82	—0.22	454.60	469.57	
25	4 22	34.0	452.87	+1.85	454.72		
					454.27	....	4.651

DUBUQUE, IOWA.

Aug. 25	2 56	99.6	497.02	—3.40	493.62		
25	3 15	95.2	496.21	—3.01	493.20		
25	3 30	98.7	496.87	—3.32	493.55	468.97	
					493.46	....	3.933

WENONA, ILL.

Aug. 29	4 45	86.5	477.50	—2.10	475.40		
29	4 59	83.9	477.19	—1.89	475.30		
29	5 15	82.9	476.79	—1.81	474.98	469.02	
					475.23	....	4.241

MACON, ILL.

Sept. 1	9 05	81.7	465.82	—1.64	464.18		
1	10 10	79.0	462.57	—1.42	461.15	469.03	
					462.66	....	4.475

HIGHLAND, ILL.

Sept. 2	3 29	100.7	458.19	—2.97	455.22		
2	3 49	98.0	457.91	—2.77	455.14		
2	4 05	97.0	457.46	—2.69	454.77	469.04	
					455.04	....	4.626

HERMANN, MO.

Sept. 27	10 09	64.6	453.76	—0.33	453.43		
27	10 42	69.8	453.75	—0.70	453.05	469.22	
					453.24	....	4.666

Observations for Intensity—Continued.

SEDALIA, MO.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n (reduction to 60° F.).	Time of 120 vibrations. At ——.	At Washington.	Horizontal intensity.
1872.	h. m.	°	s.	s.	s.	s.	
Oct. 2	9 17	68.6	447.89	—0.60	447.29		
2	9 50	72.2	448.69	—0.88	447.81		
2	10 05	74.5	449.28	—1.01	448.27	469.23	
					447.79	....	4.780

KANSAS CITY, MO.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n.	At ——.	At Washington.	Horizontal intensity.
Oct. 4	1 56	89.1	450.00	—2.05	447.95		
4	2 23	91.2	450.51	—2.20	448.31	469.26	
					448.13	....	4.773

MANHATTAN, KANS.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n.	At ——.	At Washington.	Horizontal intensity.
Oct. 6	11 31	67.8	448.50	—0.55	447.95		
6	11 49	69.1	449.01	—0.64	448.37		
6	12 12	70.0	448.82	- 0.70	448.12	469.28	
					448.15	....	4.773

ELLIS, KANS.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n.	At ——.	At Washington.	Horizontal intensity.
Oct. 10	10 03	48.0	439.67	+0.81	440.48		
10	10 15	49.0	439.73	+0.74	440.47		
10	10 49	50.9	440.22	+0.61	440.83	469.29	
10	11 09	52.8	440.83	+0.49	441.32		
					440.78	....	4.934

WALLACE, KANS.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n.	At ——.	At Washington.	Horizontal intensity.
Oct. 11	10 53	65.1	439.87	—0.34	439.53		
11	11 55	73.5	440.94	—0.91	440.03		
11	1 45	85.0	442.11	—1.70	440.41	469.29	
11	3 26	85.0	441.04	—1.70	439.34		
					439.83	....	4.956

DENVER, COLO.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n.	At ——.	At Washington.	Horizontal intensity.
Oct. 13	10 11	61.1	440.75	—0.07	440.68		
13	10 29	61.0	440.00	—0.07	439.93		
13	10 56	63.7	440.28	—0.25	440.03	469.31	
13	11 25	63.7	440.90	—0.25	440.65		
					440.32	....	4.945

PUEBLO, COLO.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n.	At ——.	At Washington.	Horizontal intensity.
Oct. 16	10 12	60.2	433.52	—0.01	433.51		
16	11 10	68.7	432.85	—0.57	432.28		
16	11 46	70.2	432.61	—0.66	431.95	469.33	
					432.58	....	5.124

Observations for Intensity—Continued.

CHEYENNE, WYO.

Date.	Time.	Temp. F.	Observed time of 120 vibrations.	Temp. corr'n (reduction to 60° F.).	Time of 120 vibrations. At ——.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1872.	*h. m.*	°	*s.*	*s.*	*s.*	*s.*	
Oct. 22	11 48	51.0	451.05	+0.59	451.64		
22	12 22	53.6	451.48	+0.45	451.93		
22	1 11	55.0	450.84	+0.35	451.19		
22	1 47	57.2	451.53	+0.20	451.73	469.36	
22	2 19	58.5	450.62	+0.11	450.73		
					451.44	....	4.705

SYDNEY, NEBR.

Oct. 25	2 00	68.0	455.01	—0.58	454.43		
25	3 14	71.5	455.62	—0.83	454.79		
25	3 38	66.2	455.10	—0.45	454.65	469.39	
					454.62	....	4.640

NORTH PLATTE, NEBR.

Oct. 26	10 56	68.9	459.56	—0.65	458.91		
26	1 52	76.6	458.00	—1.21	456.79		
26	2 15	76.7	458.44	—1.22	457.22		
26	2 45	77.2	457.79	—1.25	456.54	469.39	
26	....	75.5	458.37	—1.13	457.24		
					457.34	....	4.585

GRAND ISLAND, NEBR.

Oct. 27	11 47	68.9	460.01	—0.65	459.36		
27	12 26	70.8	460.42	—0.79	459.63		
27	2 03	79.3	462.05	—1.43	460.62	469.40	
					459.87	....	4.535

OMAHA, NEBR.

Oct. 31	9 14	47.9	469.87	+0.93	470.80		
31	9 34	51.7	471.26	+0.64	471.90		
31	10 05	52.6	470.28	+0.57	470.85	469.42	
					471.18	....	4.320

DES MOINES, IOWA.

Nov. 6	9 47	47.3	475.45	+1.00	476.45		
6	10 19	48.4	475.72	+0.92	476.64		
6	11 40	51.0	475.32	+0.71	476.03	469.45	
					467.37	....	4.228

GENERAL RESULTS.

STATIONS.

Columbus, Ohio.
Richmond, Ind.
New Albany, Ind.
Edgefield, Tenn.
Corinth, Miss.
Oxford, Miss.
Grenada, Miss.
Magnolia Base, La.
New Orleans, La.
Southwest Pass, La.
Osgood's Island, La.
Avery's Island, La.
Brashear City, La.
Baton Rouge, La.
Grand Ecore, La.
Shreveport, La.
Longview, Tex.
Alexandria, La.
Natchez, Miss.
Vicksburg, Miss.
Monroe, La.
Jackson, Miss.
Memphis, Tenn.
Golconda, Ill.
Cairo, Ill.
Saint Louis, Mo.
Dubuque, Iowa.
Wenona, Ill.
Macon, Ill.
Highland, Ill.
Hermann, Mo.
Sedalia, Mo.
Kansas City, Mo.
Manhattan, Kans.
Salina, Kans.
Ellis, Kans.
Wallace, Kans.
Denver, Colo.
Pueblo, Colo.
Cheyenne, Wyo.
Sydney, Nebr.
North Platte, Nebr.
Grand Island, Nebr.
Omaha, Nebr.
Des Moines, Iowa.

Observer, T. C. HILGARD.

MAGNETIC SURVEY, 1871-'72.

COLUMBUS, OHIO.

Date.	Declination.	Dip.	Time of 120 vibrations. At —.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1871.	° ′	° ′	s.	s.	
Nov. 18	1 14.7 E.				

COLUMBUS, OHIO. DEAN'S MAGNETIC STATION.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Nov. 20	1 10.8 E.				

RICHMOND, IND.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Nov. 24	3 16.1 E.	71 34.6			
		71 30.1			
		71 25.3			
		71 16.3			
	3 16.1 E.	71 26.6			

NEW ALBANY, IND.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Nov. 28		70 23.1	461.37	467.27	
		70 20.6	461.50		
		70 21.9	461.43	....	4.466

EDGEFIELD, TENN.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Dec. 1	5 02.0 E.	67 12.6	461.67	467.28	
		67 08.8	460.02		
	5 02.0 E.	67 10.7	460.85	....	4.478

CORINTH, MISS.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Dec. 3	5 41.1 E.	65 52.5	425.28		
	5 58.7 E.	65 56.7	425.96		
			425.93	467.31	
			425.71		
	5 49.9 E.	65 54.6	425.72	....	5.248

General Results—Continued.

OXFORD, MISS.

Date.	Declination.	Dip.	Time of 120 vibrations. At —.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1871.	° ′	° ′	s.	s.	
Dec. 24	....	65 14.7	418.70		
		64 58.4	418.48		
		65 00.9	418.47	467.45	
		64 59.7	418.59		
		65 03.4	418.56	....	5.444
1872.					
May 15	....	65 10.6	419.66		
		64 59.9	419.57		
			419.86		
			419.65		
			419.78		
			420.04		
			420.43	468.28	
			420.14		
			420.38		
			420.84		
			420.38		
			419.53		
		65 05.3	420.00	....	5.408

GRENADA, MISS.

Mar. 20	6 31.0 E.	64 28.5	415.85		
	6 18.2 E.	64 19.6	416.25		
	6 26.1 E.		416.23		
			416.85		
			416.72	468.02	
			416.41		
			415.40		
			415.81		
			415.07		
	6 25.1 E.	64 24.0	416.07	....	5.510

MAGNOLIA BASE, LA.

Jan. 20	6 46.5 E.	59 22.7	437.26		
	6 46.5 E.	59 24.3	437.29		
	6 44.1 E.		437.58	467.59	
	6 50.0 E.				
	6 46.8 E.	59 23.5	437.38	....	5.977

NEW ORLEANS, LA., CITY PARK STATION.

Feb. 12	6 39.9 E.	59 45.3	400.57		
	6 39.7 E.	59 41.7	400.56		
			399.45		
			399.17	467.75	
			399.57		
	6 39.8 E.	59 43.5	399.86	....	5.959

NEW ORLEANS, LA., FAIR GROUND STATION.

Feb. 14	6 40.4 E.	59 52.6			
	6 35.6 E.	59 44.7			
	6 42.5 E.				
	6 39.5 E.	59 48.6			

General Results—Continued.

SOUTHWEST PASS, LA. STATION NO. 1.

Date.	Declination.	Dip.	Time of 120 vibrations. At —.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1872.	° ′	° ′	s.	s.	
Mar. 2	6 05.4 E.	58 46.0	391.83		
		58 47.1	....	467.88	
	6 05.4 E.	58 46.5	391.83	....	6.209

SOUTHWEST PASS, LA. STATION NO 2.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Mar. 3	7 18.5 E.	58 43.8	391.05		
		58 51.5	391.08		
			391.07	467.86	
	7 18.5 E.	58 47.6	391.07	....	6.234

OSGOOD'S ISLAND, LA.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Mar. 5	6 17.1 E.	59 01.4	396.56		
	6 04.4 E.	59 01.0	396.23	467.90	
	6 10.7 E.	59 01.2	396.40	....	6.068

PETIT ANSE, AVERY'S ISLAND, LA.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Mar. 15	7 20.8 E.	59 26.1	398.37		
	7 18.2 E.	50 26.7	398.20	467.97	
	7 20.8 E.				
	7 19.0 E.				
	7 19.7 E.	59 26.4	398.28	....	6.012

BRASHEAR CITY, LA.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Mar. 23	6 53.1 E.	59 14.9	396.58		
		59 17.8	396.61		
			394.79	468.01	
			394.75		
	6 53.1 E.	59 16.3	395.68	....	6.093

BATON ROUGE, LA.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Apr. 4	6 57.5 E.	60 19.6	398.46		
	7 01.6 E.	60 20.5	398.37		
			398.61	468.06	
	6 59.5 E.	60 20.0	398.48	....	6.008

GRAND ECORE, LA.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Apr. 10	7 55.8 E.	61 27.0	402.22		
	7 49.1 E.	61 27.4	402.57		
			401.97	468.13	
			401.91		
	7 52.4 E.	61 27.2	402.17	....	5.901

SHREVEPORT, LA.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Apr. 14	8 00.1 E.	62 04.0	405.84		
		62 04.8	404.87	468.15	
	8 00.1 E.	62 04.4	405.35	....	5.809

General Results—Continued.

LONGVIEW, TEX.

Date.	Declination.	Dip.	Time of 120 vibrations. At —.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1872.	° ′	° ′	s.	s.	
Apr. 15	8 37.8 E.	61 55.6	405.54		
		61 59.6	406.02		
			406.32	468.16	
			406.14		
	8 37.8 E.	61 57.6	406.00	....	5.790

ALEXANDRIA, LA.

Apr. 17	7 43.9 E.	60 52.3	399.93		
		60 53.6	399.57		
			400.60	468.17	
	7 43.9 E.	60 53.0	400.03	....	5.965

NATCHEZ. MISS.

Apr. 22	7 12.5 E.	61 29.2	403.21		
	7 17.1 E.	61 24.2	403.51		
			402.63	468.20	
	7 14.8 E.	61 26.7	403.12	....	5.874

VICKSBURG, MISS.

Apr. 24	7 32.4 E.	62 27.4	407.82		
	7 22.0 E.	62 29.3	407.96		
			407.76		
			407.65	468.22	
			407.13		
			406.74		
	7 27.2 E.	62 28.4	407.51	....	5.749

MONROE, LA.

Apr. 26	7 35.5 E.	....	406.56		
			406.39	469.23	
	7 35.5 E.	....	406.48	....	5.778

JACKSON MISS.

Apr. 28	7 20.5 E.	....	410.48		
			410.30		
			410.76	468.24	
	7 20.5 E.	....	410.51	....	5.665

MEMPHIS, TENN.

May 21	....	65 37.2	424.67		
		65 37.7	424.72	468.39	
		65 37.5	424.70	....	5.296

General Results—Continued.

GOLCONDA, ILL.

Date.	Declination.	Dip.	Time of 120 vibrations. At —.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1871.	° ′	° ′	s.	s.	
Aug. 31	....	68 08.8			
31	....	68 04.8			
Sept. 1	....	68 04.3			
1	....	67 50.7			
12	....	68 14.9			
12	....	68 04.8			
18	....	67 56.1			
18	....	68 04.7			
20	....	68 04.6			
20	....	68 03.7			
22	....	68 10.4			
22	....	68 03.8			
Oct. 3	....	68 00.5			
3	....	67 56.3			
13	....	68 01.2			
13	....	67 59.3			
		68 03.1			
1872.					
June 6	6 10.1 E.	67 54.8	441.31		
	6 07.3 E.	67 57.1	442.33		
	5 59.9 E.	....	441.77		
			442.15		
			441.91	468.53	
			443.31		
			443.40		
	6 05.8 E.	67 55.9	442.31	....	4.885

CAIRO, ILL.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
June 22	....	67 40.3	440.94		
		67 42.2	441.21	468.58	
		67 41.3	441.08	....	4.914

SAINT LOUIS, MO. STATION NO. 1, COMPTON'S HILL.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
June 24	6 33.2 E.	69 32.6	455.97		
	6 34.1 E.	69 34.7	456.04		
	6 38.9 E.	69 37.3	456.12		
	6 35.0 E.	69 33.1	456.26		
	6 31.5 E.	....	454.99		
	6 35.5 E.	....	455.23		
	6 30.5 E.	....	454.69	468.64	
	6 39.9 E.				
	6 30.1 E.				
	6 33.9 E.				
	6 36.3 E.				
	6 38.8 E.				
	6 44.3 E.				
	6 33.2 E.				
	6 33.8 E.				
	6 37.1 E.				
	6 31.1 E.				
	6 32.2 E.				
	6 35.9 E.				
July 9	6 39.5 E.				
	6 35.2 E.	69 34.4	455.61	....	4.607

General Results—Continued.

SAINT LOUIS, MO. STATION NO. 1, COMPTON'S HILL—Continued.

Date.	Declination.	Dip.	Time of 120 variations. At —.	Time of 120 variations. At Washington.	Horizontal intensity.
1872.	° ′	° ′	s.	s	
Nov. 24			453.66		
			454.11		
			454.60	469.57	
			454.72		
			454.27	....	4.651

SAINT LOUIS, MO. STATION NO. 2.

July 12	6 49.2 E.				
	6 48.7 E.				
	6 48.9 E.				

SAINT LOUIS, MO. STATION NO. 3.

Aug. 3	6 53.6 E.				
	6 30.0 E.				
	6 48.6 E.				
	6 51.2 E.				
	6 34.7 E.				
	6 39.1 E.				
	6 49.0 E.				
	6 33.2 E.				
	6 38.7 E.				
	6 44.3 E.				
	6 28.9 E.				
	6 47.1 E.				
	6 32.7 E.				
	6 35.8 E.				
	6 40.1 E.				
Aug. 10	6 31.3 E.				
	6 39.9 E.				

DUBUQUE, IOWA.

Aug. 24	7 32.6 E.	73 05.6	493.62		
	7 24.6 E.	73 08.0	493.20		
	7 24.9 E.		493.55	468.97	
	7 28.2 E.				
	7 35.1 E.				
	7 43.6 E.				
Aug. 27	7 45.9 E.				
	7 33.6 E.	73 06.8	493.46	....	3.933

WENONA, ILL.

Aug. 30	6 07.6 E.	71 46.7	475.40		
	6 07.0 E.	71 41.1	475.30		
	6 16.8 E.		474.98	469.62	
	6 01.2 E.				
	6 01.6 E.				
	6 00.8 E.				
	6 08.0 E.				
	6 06.1 E.	71 43.9	475.23	....	4.241

General Results—Continued.

MACON, ILL.

Date.	Declination.	Dip.	Time of 120 vibrations. At —.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1872.	° ′	° ′	s.	s.	
Sept. 1	5 29.0 E.	70 08.8	464.18		
	5 28.2 E.	70 18.2	461.15	469.03	
	5 23.4 E.				
	5 19.4 E.				
	5 16.8 E.				
	5 17.6 E.				
	5 19.4 E.				
	5 17.5 E.				
	5 21.8 E.				
	5 21.5 E.	70 13.5	462.66	....	4.475

HIGHLAND, ILL.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Sept. 3	6 30.7 E.	69 47.7	455.22		
	6 35.4 E.	69 46.7	455.14		
	6 34.6 E.		454.77	469.04	
	6 33.5 E.				
	6 36.9 E.				
	6 34.2 E.	69 47.2	455.04	....	4.026

HERMANN, MO.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Sept. 29	8 16.5 E.	69 22 7	453.43		
	8 04.4 E.	69 19 9	453.05	469.22	
	8 17.6 E.				
	8 13.4 E.				
	8 17.3 E.				
	8 13.8 E.	69 21.3	453.24	....	4.66

SEDALIA, MO.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Oct. 2	8 17.7 E.	68 49.3	447.29		
	8 16.1 E.	68 47.7	447.81		
			448.27	469.23	
	8 16.9 E.	68 48.5	447.79	....	4.780

KANSAS CITY, MO.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Oct. 4	10 35.3 E.	69 07.8	447.95		
	10 44.5 E.	69 02.8	448.31	449.26	
	10 30.5 E.				
	10 36.8 E.	69 05.3	448.13	....	4.773

MANHATTAN, KANS.

Date.	Declination.	Dip.	At —.	At Washington.	Horizontal intensity.
Oct. 7	10 55.2 E.	68 53.4	447.95		
	10 55.2 E.	68 45.9	448.37		
	10 51.9 E.	68 45.7	448.12	469.28	
	10 56.3 E.	68 44.0			
	10 47.9 E.				
	10 45.0 E.				
	10 47.9 E.				
	10 51.3 E.	68 47.2	448.15	....	4.773

General Results—Continued.

SALINA, KANS.

Date.	Declination.	Dip.	Time of 120 vibrations.		Horizontal intensity.
			At ——.	At Washington.	
1872.	° ′	° ′	s.	s.	
Oct. 9	12 47.9 E.				

ELLIS, KANS.

Date.	Declination.	Dip.	At ——.	At Washington.	Horizontal intensity.
Oct. 10	12 24.7 E.	68 01.4	440.48		
	12 28.8 E.	67 42.0	440.47		
	12 21.2 E.	....	440.83	469.29	
			441.32		
	12 24.9 E.	67 51.7	440.78	....	4.934

WALLACE, KANS.

Date.	Declination.	Dip.	At ——.	At Washington.	Horizontal intensity.
Oct. 12	13 25.3 E.	67 32.0	439.53		
	13 17.5 E.	67 31.2	440.03		
	13 17.8 E.	....	440.41		
	13 12.0 E.	....	439.34	469.29	
	13 15.2 E.				
	13 23.3 E.				
	13 14.0 E.				
	13 17.9 E.	67 31.6	439.83	....	4.956

DENVER, COLO.

Date.	Declination.	Dip.	At ——.	At Washington.	Horizontal intensity.
Oct. 15	14 40.0 E.	67 38.6	440.68		
	14 45.7 E.	67 30.2	439.93		
	14 46.2 E.	....	440.03		
	14 52.9 E.	....	440.65	469.31	
	14 40.5 E.				
	14 45.1 E.				
	14 44.8 E.				
	14 42.6 E.				
	14 44.7 E.	67 34.4	440.32	....	4.945

PUEBLO, COLO.

Date.	Declination.	Dip.	At ——.	At Washington.	Horizontal intensity.
Oct. 17	13 56.4 E.	66 41.2	433.51		
	13 54.5 E.	66 35.4	432.28		
	13 55.7 E.	....	431.95	469.33	
	13 55.5 E.				
	13 55.5 E.	66 38.3	432.58	....	5.124

CHEYENNE, WYO.

Date.	Declination.	Dip.	At ——.	At Washington.	Horizontal intensity.
Oct. 22	15 21.8 E.	68 57.3	451.64		
	15 24.4 E.	68 58.9	451.93		
	15 33.6 E.	....	451.19		
	15 28.6 E.	....	451.73	469.36	
	15 24.5 E.	....	450.73		
	15 27.5 E.				
	15 26.7 E.	68 58.1	451.44	....	4.705

General Results—Continued.

SYDNEY, NEBR.

Date.	Declination.	Dip.	Time of 120 vibrations. At ——.	Time of 120 vibrations. At Washton.	Horizontal intensity.
1872.	° ′	° ′	s.	s.	
Oct. 25	14 35.0 E.	69 23.7	454.43		
	14 38.5 E.	69 24.0	454.79		
	14 34.5 E.	....	454.65	469.39	
	14 36.5 E.				
	14 36.5 E.				
	14 37.0 E.				
	14 40.0 E.				
	14 36.9 E.	69 23.9	454.62	....	4.640

NORTH PLATTE, NEBR.

Oct. 26	13 14.0 E.	69 33.1	458.91		
	13 05.4 E.	69 49.1	456.79		
	13 04.3 E.	....	457.22		
	13 06.2 E.	....	456.54	469.39	
			457.24		
	13 07.5 E.	69 41.1	457.34	....	4.585

GRAND ISLAND, NEBR.

Oct. 27	13 15.9 E.	70 23.0	459.36		
	13 11.9 E.	70 08.1	459.63		
	13 11.7 E.	....	460.62	469.40	
	13 14.4 E.				
	13 13.5 E.	70 15.5	459.87	....	4.535

OMAHA, NEBR.

Oct. 31	10 48.0 E.	71 07.8	470.80		
	10 43.0 E.	71 04.4	471.90		
	10 42.3 E.	....	470.85	469.42	
	10 43.6 E.				
	10 44.2 E.	71 06.1	471.18	....	4.320

DES MOINES, IOWA.

Nov. 4	9 44.8 E.	71 31.8	476.45		
	9 49.0 E.	71 29.0	476.64		
	9 49.1 E.	....	476.03	469.45	
	9 53.7 E.				
	9 47.4 E.				
	9 48.8 E.	71 30.4	476.37	....	4.228

1873.

DESCRIPTIONS OF STATIONS.

MARTINSBURG, W. VA.—The station is in the grounds of James F. Randolph, esq., to the east of the house. It is marked by a stub driven into the lawn on the right hand of the middle walk, near the curve at the lower end. The dip was observed about 15 feet south-southeast of the magnetometer.

STRASBURG, VA.—The station is on the grass on the south side of Queen street, opposite the house of J. M. Kelley, and about 30 feet from where Apple street runs into Queen street. The station marked by a stub. Dip was observed about 20 feet west of station.

CULPEPER, VA.—The station is in a pasture belonging to Mr. Peter Kelly, situated on the turnpike to Rappahannock. Station is 42 paces west by south of cedar tree standing on highest point of pasture.

CHARLOTTESVILLE, VA.—The station is in a field belonging to Mr. Slaughter Ficklin, on right of Monticello road going east. Station marked by a stub driven in the ground, 17 paces southeast of first clump of cedar trees met on the right of road to Monticello. Its position is fixed by the following angles:

	°	′
Ball on Baptist church	349	10
Presbyterian church	341	45
Thomas Jefferson's house at Monticello	139	57
Northeast chimney of Central Hotel	14	24
Southeast chimney of Central Hotel	14	00

The dip was observed 150 yards east by south of the station.

LYNCHBURG, VA.—The station is located on top of the bluff owned by Mr. Lynch. It is opposite freight station, and is the first bluff on the right after crossing the toll bridge from town. The station is marked by stub 10 paces east of cabin on top of bluff. The station is located by the following angles:

	°	′
Engine-house cupola	279	23
Court House cupola	256	33
High School cupola	243	41
Center chimney of Morris Langham's dwelling on Diamond Hill	223	35
South edge of chimney of house on same bluff	145	45

BURKESVILLE, VA.—From the smallness of the place and absence of permanent marks the station will best be found by consulting Mr. Bardwell of this place, an engineer by profession. The station is 18 paces northwest of Patrick Robinson's fence. The mark used was the belfry of the Methodist Church.

DANVILLE, VA.—The station is marked by a stub on Clayburn's Hill on north side of Dan River. It is on top of the small hill, part of Clayburn's Hill, nearly in a straight line with the end of the toll bridge. The following angles were taken:

	°	′
Cupola of Town Hall	233	47
Mark (ball of Presbyterian church)	230	35
Flag-pole of National Cemetery	195	07
North chimney of Carroll & Bass' grist-mill	182	26
Chimney of house at north end of railroad bridge	132	38
West chimney of the Clayburn mansion	357	28

Dip was taken 50 feet east of station.

GREENSBOROUGH, N. C.—The station is located on the grounds of Mr. Colwell, on Gaston street, above Green. It is marked by a stub in northeast corner of the front lawn. It is four paces from the east side of carriage road and nine paces north from front fence. The mark is the cross on the Episcopal church steeple. The following angles were measured:

	°	′
Mark	102	12
North edge of court-house roof	121	18
Methodist church spire	233	20
Southwest corner of Colwell's roof	318	24
Northeast chimney of Colwell's house	333	55

SALISBURY, N. C.—The station is located in the pasture of Mr. J. K. Burk, on Main street, just out of town, going west. It is marked by a stub 20 paces southwest of the sixth fork of the fence running north and south. The dip was taken 150 feet southwest of the station. The mark used was the flag-pole of the National Cemetery. The following angles were taken:

	°	′
Mark	163	33
Chimney of house on railroad	187	35
Northeast corner of Mr. J. K. Burk's barn	271	20
West corner of Heilig's house	3	28
South chimney of Blackmore's house	29	55

CHARLOTTE, N. C.—The station is marked by a stub in the front yard of Mr. Reidiger, living on northeast corner of Church and Sixth streets, and is three paces northeast of fence corner. Dip was taken under the second peach tree. The "mark" is the dot over XII of the clock on the Methodist church. The following angles were taken:

	°	′
Mark	152	26
Bell tower	232	53
Foot of lightning rod of Presbyterian church	251	43
North chimney of house on next street north	328	43
South ornament on Dr. Graham's house	76	00

MORGANTON, N. C.—The station is marked by a stub in the front lawn of Maj. J. W. Wilson's dwelling, opposite the Episcopal church. It is 10 paces west of the east fence and 15 south of the north fence. The mark is the northeast pineapple on the Episcopal church. The following angles were taken:

	°	′
Mark	25	50
Northwest corner of the parsonage	72	35
Southeast corner of the parsonage	88	26
Union flag-pole	153	44
Southeast chimney of Major Wilson's house	235	52
East white chimney of Rev. Mr. Anderson's	307	49
East chimney of the Mountain Hotel	345	00

ASHEVILLE, N. C.—The station is marked by a stub in the grounds attached to the Eagle Hotel. It is five paces west of the east wall and three paces north of the south wall. The dip was taken under the locust tree northwest of the station. The following angles were taken:

	°	′
Mark	174	40
Top of Rev. Buell's	245	37
Southwest corner Eagle Hotel	303	28
Southeast corner Eagle Hotel	324	15
West chimney of Carter's building	359	40
East chimney of farm house	62	10

The "mark" is the north chimney of Mr. Blair's, being the first dwelling south of the Eagle Hotel.

KNOXVILLE, TENN.—The station is in the grounds of the Asylum for the Deaf and Dumb, three paces southeast of the large tree in front of the dwelling of the director of the asylum, Professor Imes. The following angles were taken:

	°	′
Mark	198	15
North corner of house in the woods	289	57
West corner of Professor Imes's house	319	17
North chimney of asylum	118	05
Southwest corner of asylum	146	47
Cupola of residence on hill east of University	172	15

The mark is the ball on top of the University.

WILLIAMSBURG, KY.—The station is marked by a stub 10 paces southwest of southwest corner of court house. It will be preserved and pointed out by the county surveyor. The dip was observed 25 feet southeast of the station. The mark is the east chimney of the house on "Old Cock's Corner." The following angles were taken:

	°	′
Mark	107	56
Northwest chimney of Freeman's store	220	30
Northwest corner of court house	341	47
Southwest corner of court house	33	07

ROGERSVILLE, TENN.—The station is marked by a stub in the garden of Capt. F. A. Butler, keeper of the Rogersville House. It is three paces from the west fence and seven from the south fence. The mark used is base of ball on First Presbyterian church. The dip was taken 25 feet east of the station. The following angles were taken:

	°	′
Mark	159	41
Northwest corner of seminary	168	46
Northeast corner of John Hazard's	322	28
Northwest corner of the hotel	25	35
South chimney of the hotel	92	12

BRISTOL, TENN.—The station is marked by a stub in Mr. Jameson's lot on the spot occupied by the eclipse party, nearly midway between the pillar holes. It is 12 paces from the south fence and 8 paces from east fence. Dip was taken 30 feet northwest of station. The mark is the cupola of the Baptist church. The following angles were taken:

	°	′
Mark	120	52
M. Lancaster's north chimney	188	10
Billy Smith's north chimney	230	53
Mr. Williams's west chimney	304	34
Mr. Saul's middle chimney	91	58

MOUNT AIRY, VA.—The station is marked by a stub driven in the front yard of Mr. Buck's residence. It is 13 paces from the west fence and 9 from the north fence. The dip was taken 30 feet east of the station. The mark used is the west edge of the tower of the freight station. The following angles were taken:

	°	′
Mark	348	50
Northwest edge of Mr. Buck's house	174	53
Northeast edge of Mr. Buck's house	143	16
East chimney of Railroad Hotel	19	50
West chimney of J. W. Spence's house	358	00

CHRISTIANSBURG, VA.—The station is marked by a stub in the front yard of Captain Schaeffer, back of the colored Baptist church, on the first hill towards the town of Christiansburg. It is 14 paces from the west fence and 8 paces from the walk, north. The dip was taken 30 feet east of the station. The mark is the ball on the Presbyterian church in the town. The following angles were taken:

	°	′
Mark	199	55
Southeast edge of colored Baptist church	220	00
South chimney of Mr. Meyers	263	58
Northwest corner of Captain Schaeffer's house	126	28
Southwest corner of Captain Schaeffer's house	143	28

NATURAL BRIDGE, VA.—The station is marked by a stub three paces southeast of the northeast cedar tree in the grove on the hill side in front of the hotel. The mark is the north chimney of the hotel. The dip was taken 50 feet south of the station. The following angles were taken:

	°	′
Mark	102	07
North chimney Mr. Penn's	117	47
Corner of old hotel	205	24
Northeast cedar in the grove	340	05

COVINGTON, VA.—The station is marked by a stub in the garden of the McCurdy House. It is 7 paces from the east fence and 10 from the north fence. Dip was taken 30 feet west of the station. The mark is the cupola of the Presbyterian church. The following angles were taken:

	°	′
Mark	330	13
South corner Mr. McElwee's house	262	02
North corner of hotel	88	10

STAUNTON, VA.—The station occupied is the United States Coast Survey station on the hill over the railroad. It is marked by a square pillar of granite. Dip was taken 50 feet west. The mark is the acorn on top of the Presbyterian church.

HARRISONBURG, VA.—The station is in the front yard of Mr. W. B. Compton, on West Market street. It is 16 paces north of the front fence and 12 paces west of the east fence. The mark is the point of the steeple of the Baptist church. Dip was taken 30 feet north of the station. The following angles were taken:

	°	′
Mark	95	50
Ball of Methodist church	103	19
Spike on D. C. Jones's	164	05
Southwest corner of Mr. Compton's	327	50
Northeast corner of Mr. Compton's	353	24

1873.

OBSERVATIONS FOR DECLINATION.

STATIONS OCCUPIED.

Martinsburg, W. Va.	Danville, Va.	Knoxville, Tenn.	**Christiansburg, Va.**
Strasburg, Va.	Greensborough, N. C.	Williamsburg, Ky.	**Natural Bridge, Va.**
Culpeper, Va.	Salisbury, N. C.	Rogersville, Tenn.	**Covington, Va.**
Charlottesville, Va.	Charlotte, N. C.	Bristol, Tenn.	**Staunton, Va.**
Lynchburg, Va.	Morganton, N. C.	Mount Airy, Va.	**Harrisonburg, Va.**
Burkeville, Va.	Asheville, N. C.		

Observer, F. E. HILGARD.

In the observations for declination the following table was used for reducing the observed magnetic meridian to the mean of day.

Time of day.	Correction.	Time of day.	Correction.
h. m.	′	*h. m.*	′
6 00 a. m.	−3.0	0 00 p. m.	+4.5
6 30 a. m.	−3.7	0 30 p. m.	+5.0
7 00 a. m.	−4.5	1 00 p. m.	+6.0
7 30 a. m.	−5.0	1 30 p. m.	+6.0
8 00 a. m.	−6.0	2 00 p. m.	+5.0
8 30 a. m.	−6.0	2 30 p. m.	+4.5
9 00 a. m.	−5.0	3 00 p. m.	+3.0
		4 00 p. m.	+1.5

These corrections are to be applied to the reading of the observed magnetic meridian.

OBSERVATIONS FOR DECLINATION.

MAGNETIC SURVEY, 1873.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
					MARTINSBURG, W. VA. $\phi = 39^\circ 26'.7$						
1873.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
July 10, a. m.	61 15.2	83 51.0	234 40.4	150 49.4	180 00.0	29 10.6	....	32 00.0	2 50.5	W.	July 9, a. m.
10, a. m.	57 40.7	86 38.0	237 29.5	150 51.5	180 00.0	29 08.5	29 09.5	32 02.5	2 53.0	W.	9, a. m.
									2 51.7	W.	
					STRASBURG, VA. $\phi = 38^\circ 44'$						
July 11, a. m.	62 37.7	82 40.8	114 00.7	31 19.9	360 00.0	328 40.1	....	330 52.5	2 10.4	W.	July 11, a. m.
11, p. m.	66 29.9	279 58.7	311 14.6	31 15.9	360 00.0	328 44.1	328 42.1	331 04.5	2 22.4	W.	11, p. m.
									2 16.4	W.	
					CULPEPER, VA. $\phi = 38^\circ 25'.5$						
July 14, a. m.	65 31.8	81 00.3	276 31.0	195 30.7	360 00.0	164 29.3					
14, a. m.	61 33.2	83 54.7	279 22.1	195 27.4	360 00.0	164 32.6	164 30.9	166 52.0	2 21.1	W.	July 14, p. m.
					CHARLOTTESVILLE, VA. $\phi = 38^\circ 00'$						
July 16, a. m.	55 26.1	88 43.8	289 51.4	201 07.6	180 00.0	338 52.4	....	340 12.0	1 17.3	W.	July 16, a. m.
17, a. m.	68 56.5	79 03.4	280 06.4	201 03.0	180 00.0	338 57.0	338 54.7	340 11.5	1 16.8	W.	16, p. m.
									1 17.0	W.	
					LYNCHBURG, VA. $\phi = 37^\circ 23'.7$						
July 19, p. m.	70 45.7	281 50.3	34 46.1	112 55.8	360 00.0	247 04.2	....	247 40.0 }	0 38.1	W.	July 21, a. m.
21, a. m.	59 40.8	86 27.3	199 28.7	113 01.4	360 00.0	246 58.6	....	247 37.5 }			21, a. m.
21, a. m.	57 53.2	87 46.8	200 47.5	113 00.7	360 00.0	246 59.3	247 00.7	247 30.0	0 29.3	W.	21, p. m.
									0 33.7	W.	
					BURKEVILLE, VA. $\phi = 37^\circ 13'.2$						
July 23, a. m.	67 19.9	81 26.3	279 47.2	198 20.9	360 00.0	161 39.1	161 39.1	163 35.0 }	1 55.9	W.	July 23, a. m.
								163 35.0 }			23, a. m.
								163 42.5	2 03.4	W.	23, p. m.
									1 59.7	W.	

Observations for Declination—Continued.

DANVILLE, VA. $\phi=36° 46'.6$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
1873.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
July 24, a. m.	66 34.5	82 05.8	220 58.1	138 52.3	360 00.0	221 07.7	221 07.7	222 22.6	1 14.9	W.	July 26, a. m.
								222 25.5	1 17.8	W.	26, p. m.
									1 16.3	W.	

GREENSBOROUGH, N. C. $\phi=36° 03'.5$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
July 29, p. m.	69 02.8	278 15.0	184 28.0	266 13.0	360 00.0	93 47.0	93 47.0	93 01.5	0 45.5	E.	July 28, a. m.
								93 06.5	0 40.5	E.	28, p. m.
									0 43.0	E.	

SALISBURY, N. C. $\phi=35° 40'.4$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
July 30, a. m.	62 10.1	86 28.3	290 47.1	204 18.8	360 00.0	155 41.2	....	154 48.5	0 53.4	E.	July 30, a. m.
30, a. m.	60 06.5	87 53.9	292 11.2	204 17.3	360 00.0	155 42.7	155 41.9	154 51.0	0 50.9	E.	30, p. m.
									0 52.1	E.	

CHARLOTTE, N. C. $\phi=35° 14'.0$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 1, a. m.	63 50.1	85 48.0	300 46.7	214 58.7	360 00.0	145 01.3	....	144 00.0	1 00.9	E.	Aug. 1, a. m.
1, a. m.	61 41.9	87 14.5	302 14.0	214 59.5	360 00.0	145 00.5	145 00.9	143 54.0	1 06.9	E.	1, p. m.
									1 03.9	E.	

MORGANTON, N. C. $\phi=35° 47'.4$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 5, p. m.	69 42.8	276 30.3	256 54.5	340 24.2	360 00.0	19 35.8	....	18 33.5	1 02.5	E.	Aug. 5, a. m.
5, p. m.	70 32.4	277 03.7	257 27.5	340 23.8	360 00.0	19 36.2	19 36.0	18 16.5	1 19.5	E.	5, p. m.
									1 11.0	E.	

ASHEVILLE, N. C. $\phi=35° 35'.0$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 7, a. m.	80 18.2	76 45.2	280 45.0	203 59.8	360 00.0	156 00.2	156 00.2	154 02.0	1 58.2	E.	Aug. 7, a. m.

KNOXVILLE, TENN. $\phi=35° 57'.3$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 11, a. m.	80 59.9	77 41.7	246 44.1	169 02.4	360 00.0	190 57.6	190 57.6	189 07.0	1 50.6	E.	Aug. 11, a. m.
								189 03.0	1 54.6	E.	11, p. m.
									1 52.6	E.	

WILLIAMSBURG, KY. $\phi=36° 47'$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 14, a. m.	61 43.8	93 00.7	352 16.9	259 16.2	360 00.0	100 43.8	100 43.8	98 42.0	2 01.8	E.	Aug. 14, a. m.
								98 37.5	2 06.3	E.	14, p. m.
									2 04.0	E.	

ROGERSVILLE, TENN. $\phi=36° 25'$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 18, a. m.	64 16.4	92 35.0	300 18.0	207 43.0	360 00.0	152 17.0	152 17.0	150 29.5	1 47.5	E.	Aug. 18, a. m.
								150 26.5	1 50.5	E.	18, p. m.
									1 49.0	E.	

BRISTOL, TENN. $\phi=36° 35'.9$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 21, a. m.	68 28.4	90 48.4	336 28.9	245 40.5	360 00.0	114 19.5	114 19.5	113 01.0	1 18.5	E.	Aug. 20, p. m.
								112 59.0	1 20.5	E.	21, a. m.
									1 19.5	E.	

Observations for Declination—Continued.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
MOUNT AIRY, VA. $\phi = 36° 51'.5$											
1873.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
Aug. 22, a. m	63 57.2	94 52.8	114 25.6	19 32.8	360 00.0	340 27.2	340 27.2	339 30.0	0 57.2	E.	Aug. 21, p. m.
								339 34.0	0 53.2	E.	22, a. m.
									0 55.2	E.	
CHRISTIANSBURG, VA. $\phi = 37° 11'.3$											
Aug. 23, a. m.	66 05.0	93 48.6	263 00.1	169 11.5	360 00.0	190 48.5	190 48.5	190 16.5	0 32.0	E.	Aug. 26, a. m.
								190 11.5	0 37.0	E.	26, p. m.
									0 34.5	E.	
NATURAL BRIDGE, VA. $\phi = 37° 35'$											
Aug. 26, a. m.	64 36.9	96 37.5	183 41.0	87 03.5	180 00.0	92 56.5	92 56.5	93 03.5	0 07.0	W.	Aug. 26, a. m.
								92 59.0	0 02.5	W.	26, p. m.
									0 04.7	W.	
COVINGTON, VA. $\phi = 37° 49'$											
Aug. 30, p. m.	73 19.3	268 11.3	305 37.5	37 26.2	360 00.0	322 33.8	....	322 59.5	0 24.9	W.	Aug. 30, a. m.
30, p. m.	74 54.1	269 25.6	306 50.2	37 24.6	360 00.0	322 35.4	322 34.6	322 54.0	0 19.4	W.	30, p. m.
									0 22.1	W.	
STAUNTON, VA. $\phi = 38° 08'.9$											
Sept. 1, a. m.	66 51.3	98 00.6	273 22.1	175 21.5	180 00.0	4 38.5	....	5 26.5	0 47.9	W.	Sept. 1, a. m.
1, a. m.	65 26.5	99 13.9	274 35.2	175 21.3	180 00.0	4 38.7	4 38.6	5 22.0	0 43.4	W.	1, p. m.
									0 45.6	W.	
HARRISONBURG, VA. $\phi = 38° 25'$											
				95 50	....	....	....	88 06.0	1 26.0	W.	Sept. 2, p. m.
				95 50	....	....	*86 40.0	88 10.0	1 30.0	W.	3, a. m.
									1 28.0	W.	

* Determined by U. S. Coast Survey at subsequent date.

1873.

OBSERVATIONS FOR LOCAL TIME.

STATIONS.

Martinsburg, W. Va.	Danville, Va.	Asheville, N. C.	Mount Airy, Va.
Strasburg, Va.	Greensborough, N. C.	Knoxville, Tenn.	Christiansburg, Va.
Culpeper, Va.	Salisbury, N. C.	Williamsburg, Ky.	Natural Bridge, Va.
Charlottesville, Va.	Charlotte, N. C.	Rogersville, Tenn.	Covington, Va.
Lynchburg, Va.	Morganton, N. C.	Bristol, Tenn.	Staunton, Va.
Burkesville, Va.			

OBSERVATIONS FOR LOCAL TIME.

MAGNETIC SURVEY, 1873.

MARTINSBURG, W. VA. $\phi = 39° 26'.7$.

Date.	Corrected Z. D. ☉.	Mean time of obs'n.	Time by chronometer.	Chronometer fast.
1873.	° ′	h. m. s.	h. m. s.	m. s.
July 10, a. m.	61 15.2	7 23 46	7 25 29	1 43
10, a. m.	57 40.7	7 42 22	7 44 31	2 09

STRASBURG, VA. $\phi = 38° 44'$.

July 11, a. m.	62 37.7	7 17 35	7 20 40	3 05
11, p. m.	66 29.9	5 11 56	5 15 08	3 12

CULPEPER, VA. $\phi = 38° 25'.5$.

July 14, a. m.	65 31.8	7 04 23	7 06 09	1 46
14, a. m.	61 33.2	7 24 55	7 26 41	1 46

CHARLOTTESVILLE, VA. $\phi = 38° 00'.0$.

July 16, a. m.	55 26.1	7 57 19	8 00 49	3 30
17, a. m.	68 56.5	6 48 49	6 52 37	3 48

LYNCHBURG, VA. $\phi = 37° 23'.7$.

July 19, p. m.	70 45.7	5 30 30	5 37 12	6 42
21, a. m.	59 40.8	7 38 39	7 45 31	6 52
21, a. m.	57 53.2	7 47 49	7 54 33	6 44

BURKESVILLE, VA. $\phi = 37° 13'.2$.

July 23, a. m.	67 19.9	7 01 21	7 04 17	2 56

DANVILLE, VA. $\phi = 36° 46'.6$.

July 24, a. m.	66 34.5	7 06 03	7 14 27	8 24

GREENSBOROUGH, N. C. $\phi = 36° 03'.5$.

July 29, p. m.	69 02 8	5 14 56	5 24 41	9 45

SALISBURY, N. C. $\phi = 35° 40'.4$.

July 30, a. m.	62 10.1	7 32 07	7 42 25	10 18
30, a. m.	60 06.5	7 42 17	7 53 28	11 11

CHARLOTTE, N. C. $\phi = 35° 14'.0$.

Aug. 1, a. m.	63 50.1	7 25 14	7 36 50	11 36
1, a. m.	61 41.9	7 35 42	7 47 18	11 36

MORGANTON, N. C. $\phi = 35° 47'.4$.

Aug. 5, p. m.	69 42.8	5 12 44	5 28 03	15 19
5, p. m.	70 32.4	5 16 50	5 32 06	15 16

ASHEVILLE, N. C. $\phi = 35° 35'.0$.

Aug. 7, a. m.	80 18.2	6 06 49	6 25 34	18 45

Observations for Local Time—Continued.

KNOXVILLE, TENN. $\phi = 35° 57'.3$.

Date.	Corrected. Z. D. ⊙.	Mean time of obs'n.	Time by chronometer.	Chronometer fast.
1873.	° ′	*h. m. s.*	*h. m. s.*	*m. s.*
Aug. 11, a. m.	80 59.9	6 04 06	6 30 20	26 14

WILLIAMSBURG, KY. $\phi = 36° 47'$.

Aug. 14, a. m.	61 43.8	7 43 45	8 09 41	25 56

ROGERSVILLE, TENN. $\phi = 36° 25'$.

Aug. 18, a. m.	64 16.4	7 33 43	7 55 26	21 43

BRISTOL, TENN. $\phi = 36° 35'.9$.

Aug. 21, a. m.	68 28.4	7 14 32	7 32 30	17 58

MOUNT AIRY, VA. $\phi = 36° 51'5$.

Aug. 22, a. m.	63 57.2	7 38 19	7 52 12	13 53

CHRISTIANSBURG, VA. $\phi = 37° 11'.3$.

Aug. 23, a. m.	66 05.0	7 28 28	7 39 05	10 37

NATURAL BRIDGE, VA. $\phi = 37° 35'.0$.

Aug. 26, a. m.	64 36.9	7 38 23	7 45 08	6 45

COVINGTON, VA. $\phi = 37° 49'$.

Aug. 30, p. m.	73 19.3	5 02 48	5 12 09	9 21
30, p. m.	74 54.1	5 10 50	5 20 07	9 17

STAUNTON, VA. $\phi = 38° 08'.9$.

Sept. 1, a. m.	66 51.3	7 32 11	7 37 51	5 40
1, a. m.	65 26.5	7 39 27	7 45 07	5 40

1873.

OBSERVATIONS FOR DIP.

STATIONS.

Martinsburg, W. Va.
Strasburg, Va.
Culpeper, Va.
Charlottesville, Va.
Lynchburg, Va.
Burkesville, Va.
Danville, Va.
Greensborough, N. C.
Salisbury, N. C.
Charlotte, N. C.
Morganton, N. C.
Asheville, N. C.
Knoxville, Tenn.
Williamsburg, Ky.
Rogersville, Tenn.
Bristol, Tenn.
Mount Airy, Va.
Christiansburg, Va.
Natural Bridge, Va.
Covington, Va.
Staunton, Va.
Harrisonburg, Va.

Observer, J. M. POOLE.

OBSERVATIONS FOR DIP.

Magnetic Survey, 1873.

MARTINSBURG, W. VA.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
1873.		° ′	′	′	° ′	′	′	° ′
July 9, a. m.	1	70 34.5	136.2	85.3	70 122.7	58.2	90.5	71 27.9
9, p. m.	1	70 43.7	127.7	85.7	70 104.5	46.2	75.3	71 20.5
9, a. m.	2	70 68.7	109.2	89.0	70 167.0	36.0	101.5	71 35.2
9, p. m.	2	70 43.5	99.7	71.6	70 142.5	22.0	82.2	71 16.9
								71 25.1

STRASBURG, VA.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
July 11, a. m.	1	70 09.0	98.0	53.5	70 91.5	21.0	56.2	70 54.8
11, p. m.	1	70 15.2	95.7	55.5	70 97.0	35.2	66.1	70 60.8
11, a. m.	2	70 11.2	81.7	46.5	70 117.5	12.7	65.0	70 55.7
11, p. m.	2	70 21.7	65.5	43.6	70 113.0	14.5	63.7	70 53.6
								70 56.2

CULPEPER, VA.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
July 14, a. m.	1	69 56.0	149.0	102.5	69 149.0	57.0	103.0	70 42.7
14, p. m.	1	69 55.5	149.0	102.2	69 145.0	50.5	97.7	70 40.0
14, a. m.	2	69 60.2	153.7	107.0	69 151.7	41.7	96.7	70 41.8
14, p. m.	2	69 58.7	144.7	101.7	69 153.7	56.7	105.2	70 43.5
								70 42.0

CHARLOTTESVILLE, VA.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
July 16, a. m.	1	69 34.0	123.2	78.6	69 124.0	24.7	89.3	70 23.9
16, p. m.	1	69 34.0	125.7	79.8	69 122.0	28.7	75.3	70 17.6
16, a. m.	2	69 33.7	135.2	84.5	69 109.5	37.0	73.2	70 18.8
16, p. m.	2	69 33.2	116.5	75.0	69 131.5	36.7	84.1	70 19.5
								70 20.0

LYNCHBURG, VA.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
July 19, a. m.	1	69 02.5	84.2	43.3	69 83.2	08.7	46.0	69 44.6
19, p. m.	1	69 06.7	83.2	45.0	69 83.2	06.7	45.0	69 45.0
19, a. m.	2	69 07.7	84.0	45.9	69 85.7	08.3	47.0	69 46.4
19, p. m.	2	69 06.2	83.2	44.7	69 82.2	08.7	45.5	69 45.1
								69 45.3

BURKESVILLE, VA.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
July 22, a. m.	1	68 28.2	132.5	80.9	68 133.5	27.5	80.5	69 20.7
23, p. m.	1	68 30.8	130.0	80.4	68 128.5	31.5	80.0	69 20.2
22, a. m.	2	68 29.5	132.0	80.7	68 132.8	28.5	80.6	69 20.7
23, p. m.	2	68 32.0	127.5	79.8	68 127.5	34.0	80.7	69 20.2
								69 20.4

DANVILLE, VA.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
July 25, a. m.	1	68 05.7	102.5	54.1	68 99.7	04.8	52.3	68 53.2
25, p. m.	1	68 02.5	111.3	56.9	68 110.3	02.5	56.4	68 56.6
25, a. m.	2	68 07.3	100.5	53.9	68 99.5	03.7	51.6	68 52.8
25, p. m.	2	68 09.0	105.0	57.0	68 109.0	03.5	56.2	68 56.6
								68 54.8

Observations for Dip—Continued.

GREENSBOROUGH, N. C.

Date.	Needle.	Polarity N. Circle E.	Polarity N. W.	Mean.	Polarity S. Circle W.	Polarity S. E.	Mean.	Dip.
1873.		° ′	′	′	° ′	′	′	° ′
July 28, a. m.	1	67 51.8	144.0	97.4	67 142.5	51.5	97.0	68 37.4
28, p. m.	1	67 42.5	148.2	95.3	67 144.0	43.0	93.5	68 34.4
28, a. m.	2	67 47.0	142.0	94.5	67 145.0	46.0	95.5	68 35.0
28, p. m.	2	67 46.8	143.0	94.9	67 143.0	45.0	94.0	68 34.4
								68 35.3

SALISBURY, N. C.

July 29, a. m.	1	67 06.5	83.5	45.0	67 85.5	01.3	43.4	67 44.2
30, p. m.	1	67 06.5	88.0	47.3	67 87.5	10.0	48.7	67 47.0
29, a. m.	2	67 04.0	84.0	44.0	67 86.5	08.8	47.1	67 45.6
30, p. m.	2	67 07.5	88.0	47.8	67 86.0	06.8	46.4	67 47.1
								67 46.0

CHARLOTTE, N. C.

Aug. 1, a. m.	1	66 27.0	109.0	68.0	66 111.7	25.5	68.6	67 08.3
1, p. m.	1	66 28.0	106.2	67.1	66 108.0	27.0	67.5	67 07.3
1, a. m.	2	66 25.8	106.0	65.9	66 108.8	27.7	68.3	67 07.1
1, p. m.	2	66 26.0	108.0	67.0	66 108.0	26.8	67.4	67 07.2
								67 07.5

MORGANTON, N. C.

Aug. 5, a. m.	1	66 31.2	114.8	73.0	66 118.0	33.8	75.9	67 14.4
5, p. m.	1	66 31.0	118.8	74.9	66 118.5	30.0	74.3	67 14.6
5, a. m.	2	66 34.5	114.8	74.6	66 122.8	32.0	77.4	67 16.0
5, p. m.	2	66 30.8	121.5	76.1	66 121.5	32.5	77.0	67 16.2
								67 15.3

ASHEVILLE, N. C.

Aug. 7, a. m.	1	66 32.3	146.5	89.4	66 148.8	28.5	88.7	67 29.1
7, p. m.	1	66 24.5	143.5	84.0	66 141.0	29.3	85.2	67 24.6
7, a. m.	2	66 31.0	144.5	87.8	66 146.5	28.8	87.6	67 27.7
7, p. m.	2	66 29.8	142.0	85.9	66 137.8	32.7	85.2	67 25.6
								67 26.7

KNOXVILLE, TENN.

Aug. 11, a. m.	1	66 11.5	101.8	56.6	66 99.5	10.3	54.6	66 55.6
11, p. m.	1	66 15.0	99.0	54.0	66 94.5	15.0	54.5	66 54.3
11, a. m.	2	66 14.0	100.5	57.2	66 96.0	14.0	55.0	66 56.1
11, p. m.	2	66 17.0	95.0	56.0	66 93.5	16.0	54.8	66 55.4
								66 55.3

WILLIAMSBURG, KY.

Aug. 14, a. m.	1	67 26.0	137.5	81.7	67 131.0	28.8	79.9	68 20.8
14, p. m.	1	67 35.3	137.7	86.5	67 139.5	36.5	88.0	69 27.2
14, a. m.	2	67 35.5	136.5	86.0	67 137.0	50.5	93.8	69 29.9
14, p. m.	2	67 36.5	132.0	84.2	67 134.0	38.0	86.0	68 25.1
								68 25.7

Observations for Dip—Continued.

ROGERSVILLE, TENN.

Date.	Needle.	Polarity N.		Mean.	Polarity S.		Mean.	Dip.
		Circle E.	W.		Circle W.	E.		
1873.		° ′	′	′	° ′	′	′	° ′
Aug. 18, a. m.	1	67 27.3	144.5	85.9	67 145.8	27.0	86.4	68 26.2
18, p. m.	1	67 27.5	146.5	87.0	67 145.0	26.2	85.6	68 26.3
18, a. m.	2	67 28.5	142.0	85.2	67 143.5	28.5	86.0	68 25.6
18, p. m.	2	67 27.8	147.2	87.5	67 145.5	27.3	86.4	68 26.9
								68 26.2

BRISTOL, TENN.

Date.	Needle.	Circle E.	W.	Mean.	Circle W.	E.	Mean.	Dip.
Aug. 20, p. m.	1	67 43.0	102.5	72.8	67 101.0	45.0	73.0	68 12.9
21, a. m.	1	67 37.5	103.5	70.5	67 103.0	37.0	70.0	68 10.2
20, p. m.	2	67 41.3	102.5	71.9	67 100.5	40.5	70.5	68 11.2
21, a. m.	2	67 37.0	100.5	68.8	66 103.0	39.0	71.0	68 09.9
								68 11.0

MOUNT AIRY, VA.

Date.	Needle.	Circle E.	W.	Mean.	Circle W.	E.	Mean.	Dip.
Aug. 21, p. m.	1	68 04.5	106.0	55.3	68 105.0	06.8	55.9	68 55.6
22, a. m.	1	68 05.5	101.0	53.2	68 104.7	05.5	55.1	68 54.1
21, p. m.	2	68 04.2	105.0	54.6	68 106.0	05.2	55.6	68 55.1
22, a. m.	2	68 04.0	104.5	54.3	68 103.0	04.5	53.7	68 54.0
								68 54.7

CHRISTIANSBURG, VA.

Date.	Needle.	Circle E.	W.	Mean.	Circle W.	E.	Mean.	Dip.
Aug. 23, a. m.	1	68 16.5	108.0	62.2	68 105.0	12.5	58.7	69 00.5
23, p. m.	1	68 15.0	105.5	60.3	68 108.2	18.0	63.1	69 01.7
23, a. m.	2	68 18.7	99.5	59.1	68 111.0	15.0	63.0	69 01.0
23, p. m.	2	68 17.5	101.5	59.5	68 108.0	17.5	62.7	69 01.1
								69 01.1

NATURAL BRIDGE, VA.

Date.	Needle.	Circle E.	W.	Mean.	Circle W.	E.	Mean.	Dip.
Aug. 27, a. m.	1	68 51.0	155.0	103.0	68 155.0	49.2	102.1	69 42.5
27, p. m.	1	68 50.5	152.0	101.2	68 156.5	50.0	103.3	69 42.2
27, a. m.	2	68 52.8	155.0	103.9	68 156.5	50.2	103.5	69 43.7
27, p. m.	2	68 54.8	154.0	104.4	68 153.5	50.5	102.0	69 43.2
								69 42.9

COVINGTON, VA.

Date.	Needle.	Circle E.	W.	Mean.	Circle W.	E.	Mean.	Dip.
Aug. 29, a. m.	1	68 58.0	158.0	108.0	68 157.0	58.0	107.5	69 47.7
29, p. m.	1	68 57.5	157.0	107.3	68 155.5	58.0	106.7	69 47.0
29, a. m.	2	68 58.7	156.5	107.6	68 157.5	58.0	107.8	69 47.7
29, p. m.	2	68 57.5	156.0	106.7	68 156.0	57.8	106.9	69 46.8
								69 47.3

STAUNTON, VA.

Date.	Needle.	Circle E.	W.	Mean.	Circle W.	E.	Mean.	Dip.
Sept. 1, a. m.	1	69 07.3	106.5	56.9	69 107.0	04.0	55.5	69 56.2
1, p. m.	1	69 03.5	105.3	54.9	69 105.5	06.0	55.7	69 55.3
1, a. m.	2	69 06.5	77.5	42.0	69 109.0	05.5	57.2	69 49.6
1, p. m.	2	69 07.5	102.5	55.0	69 106.0	04.5	55.2	69 55.1
								69 54.1

Observations for Dip—Continued.

HARRISONBURG, VA.

Date.	Needle.	Polarity N. Circle E.	Polarity N. W.	Mean.	Polarity S. Circle W.	Polarity S. E.	Mean.	Dip.
1873.		° ′	′	′	° ′	′	′	° ′
Sept. 2, p. m.	1	69 46.8	135.0	90.9	69 133.7	45.5	89.6	70 30.2
3, a. m.	1	69 47.0	130.5	88.7	69 129.5	46.0	87.8	70 28.2
2, p. m.	2	69 44.8	133.0	88.9	69 131.5	48.5	90.0	70 29.5
3, a. m.	2	69 45.0	129.5	87.3	69 129.5	47.5	88.5	70 27.9
								70 28.9

1873.

OBSERVATIONS FOR HORIZONTAL INTENSITY.

STATIONS.

Martinsburg, W. Va.
Strasburg, Va.
Culpeper, Va.
Charlottesville, Va.
Lynchburg, Va.
Burkesville, Va.
Danville, Va.
Greensborough, N. C.
Salisbury, N. C.
Charlotte, N. C.
Morganton, N. C.
Asheville, N. C.
Knoxville, Tenn.
Williamsburg, Ky.
Rogersville, Tenn.
Bristol, Tenn.
Mount Airy, Va.
Christiansburg, Va.
Natural Bridge, Va.
Covington, Va.
Staunton, Va.
Harrisonburg, Va.

Observer, F. E. HILGARD.

The absolute horizontal force is obtained by comparison with Washington in the following manner:

By observation March 30, 1873, the magnet made 120 vibrations in 470ˢ.51 at a temperature of 60°, and on September 8 in 472ˢ.77. Interpolating in proportion to the time, we form the table which follows the last of the stations made in 1873, viz, Harrisonburg, Va., from which the time of 120 vibrations of the magnet at Washington is derived for any intermediate date of observation.

Moreover, the absolute horizontal force at Washington for that period being found H = 4.345 by the observations made for the Coast Survey by C. A. Schott, each station is computed by the formula

$$H_1 = \frac{T^2}{T_1^2} \times H.$$

The table gives the values of log T^2 H for the several dates.

REDUCTION FOR TEMPERATURE.

T	Reduction for 1°.
s.	
437	0.061
444	0.062
451	0.063
459	0.064
466	0.065
473	0.066
480	0.067
487	0.068

OBSERVATIONS FOR INTENSITY.

Magnetic Survey, 1873.

MARTINSBURG, W. VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
1873.	h. m.	°	s.	s.	s.	s.		
July 9	9 13	83.5	479.5	1.57	477.93			
9	10 56	83.5	479.5	1.57	477.93			
9	6 12	76.5	479.8	1.10	478.76	471.79	....	4.231
					478.20			

STRASBURG, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
July 11	7 05	75	473.4	0.990	472.41			
12	6 56	66	471.3	0.396	470.90			
12	7 51	78	470.7	1.18	469.52	471.93	....	4.375
12	8 09	82	472.0	1.45	470.55			
					470.84			

CULPEPER, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
July 14	9 35	92	467.7	2.08	465.63			
14	6 42	83	465.3	1.49	463.80	471.93	....	4.492
14	7 00	81	464.4	1.36	463.04			
					464.16			

CHARLOTTESVILLE, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
July 16	7 10	75	470.4	0.99	469.41			
16	7 29	78	470.4	1.18	469.22			
16	5 46	84	466.1	1.56	464.54	471.93	....	4.428
16	6 12	86	468.6	1.69	466.91			
					467.52			

LYNCHBURG, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
July 19	6 25	85	458.5	1.60	456.90			
19	6 40	84	457.9	1.53	456.40			
21	6 35	69	456.4	0.57	455.83			
21	6 51	70	456.6	0.06	456.54	472.07	....	4.646
21	6 30	81.5	458.6	1.37	457.23			
21	6 46	78	457.4	1.15	456.25			
					456.52			

BURKESVILLE, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
July 23	4 24	102	460.7	2.68	458.02			
23	4 40	98	461.1	2.43	458.67			
23	4 55	97.5	460.9	2.40	458.50	472.07	....	4.609
24	6 05	88	460.1	1.79	458.31			
					458.37			

DANVILLE, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
July 26	6 50	85	454.9	1.57	453.33			
26	7 05	83	452.8	1.44	451.36			
26	4 12	94	454.6	2.14	452.46	472.07	....	4.727
26	4 28	89	455.3	1.82	453.48			
					452.66			

Observations for Intensity—Continued.

GREENSBOROUGH, N. C.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
1873.	h. m.	°	s.	s.	s.	s.		
July 28	6 05	76	445.1	0.99	444.11			
28	6 19	76	445.5	0.99	444.51			
28	6 36	75	445.4	0.93	444.47			
28	6 49	75	445.8	0.93	444.87	472.07	....	4.901
28	7 31	80	446.1	1.24	444.86			
					444.56			

SALISBURY, N. C.

July 30	6 08	86.5	440.8	1.61	439.19			
30	6 39	88.5	440.5	1.73	438.77	472.07	....	5.021
30	5 06	100.0	442.3	2.48	439.82			
					439.26			

CHARLOTTE, N. C.

Aug. 1	6 04	80	435.3	1.22	434.08			
1	6 27	97	437.3	2.25	435.05	472.22	....	5.089
1	4 26	104	440.4	2.68	437.72			
1	4 40	104	441.2	2.72	438.48			
					436.33			

MORGANTON, N. C.

Aug. 5	4 20	80	438.75	1.22	437.48			
5	4 34	80	439.40	1.22	438.18			
6	6 04	66	437.40	0.36	437.04	472.22	....	5.067
6	6 49	74	437.50	0.85	436.65			
					437.34			

ASHEVILLE, N. C.

Aug. 7	6 34	85	438.40	1.52	436.88			
7	6 51	85	439.85	1.52	438.33	472.22	....	5.078
7	5 35	74	437.00	0.85	436.15			
7	5 50	73	437.00	0.79	436.21			
					436.89			

KNOXVILLE, TENN.

Aug. 11	7 05	85	438.3	1.52	436.78			
11	7 18	87	439.2	1.64	437.56			
11	4 18	87	437.4	1.64	435.76	472.36	....	5.093
11	4 35	86	438.6	1.58	437.02			
					436.78			

WILLIAMSBURG, KY.

Aug. 14	6 45	77.5	444.2	1.08	443.12			
14	7 05	75	444.8	0.92	443.88			
14	4 20	75	444.3	0.92	443.38	472.36	....	4.933
14	4 33	74	443.8	0.86	442.94			
					443.33			

Observations for Intensity—Continued.

ROGERSVILLE, TENN.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T		H	
					Corrected.	Washington.	Relative.	Absolute.
1873.	h. m.	°	s.	s.	s.	s.		
Aug. 18	6 05	73	441.35	0.80	440.55			
18	6 17	74	441.60	0.86	440.74			
18	4 05	83	443.20	1.42	441.78	472.36	....	4.982
18	4 20	83	443.10	1.42	441.68			
					441.19			

BRISTOL, TENN.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
Aug. 20	4 49	81.5	445.8	1.33	444.47			
20	5 05	78.5	445.1	1.14	443.96			
21	6 10	75	447.3	0.93	446.37	472.50	....	4.900
21	6 23	80	446.1	1.24	444.86			
					444.91			

MOUNT AIRY, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
Aug. 21, p. m.	4 05	85	453.7	1.57	452.13			
21, p. m.	4 45	80	450.0	1.26	448.34			
22, a. m.	6 19	71	449.8	0.69	449.11	472.50	....	4.793
22, a. m.	6 31	74	450.8	0.87	449.93			
					449.88			

CHRISTIANSBURG, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
Aug. 23	6 20	64	453.10	0.25	452.85			
23	6 32	65	452.85	0.31	452.54			
23	6 40	65.5	453.00	0.34	452.66			
23	3 55	84.5	456.30	1.56	454.74	472.50	....	4.717
23	4 10	87	456.50	1.72	454.78			
					453.51			

NATURAL BRIDGE, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
Aug. 26	6 05	76	459.8	1.02	458.78			
26	6 17	89.5	461.4	1.88	459.57			
26	6 50	91.5	462.1	2.01	460.09			
26	4 05	80	460.0	1.28	458.72	472.50	....	4.60
26	4 45	80	460.0	1.28	458.72			
					459.18			

COVINGTON, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
Aug. 30	6 30	62	458.4	0.12	458.28			
30	6 45	63.5	458.1	0.19	457.91			
30	4 05	83.5	463.4	1.52	461.88	472.64	....	4.584
30	4 35	90	464.5	1.95	462.55			
					460.15			

STAUNTON, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
Sept. 1	6 35	82.5	466.6	1.35	465.25			
1	6 50	88.5	467.3	1.75	465.55			
1	4 25	80	465.8	1.32	464.48	472.64	....	4.489
1	4 40	80	465.9	1.32	464.58			
					464.96			

Observations for Intensity—Continued.

HARRISONBURG, VA.

Date.	Time.	Temp.	Observed time of 120 vibrations.	Reduction to 60°.	T Corrected.	T Washington.	H Relative.	H Absolute.
1873.	h. m.	°	s.	s.	s.	s.		
Sept. 2	4 20	90.0	471.8	1.98	469.82			
2	4 35	91.0	471.8	2.04	469.76			
3	6 30	73	465.9	0.84	465.06	472.64	....	4.437
3	6 45	80	467.4	1.30	466.10			
					467.68			

WASHINGTON HORIZONTAL FORCE.

Date.			Observed time of 120 vibrations.		Log T² H.			
			s.					
July 1	....	....	471.79	....	5.98549			
11	....	....	471.93	....	575			
21	....	....	472.07	....	601			
Aug. 1	....	....	472.22	....	627			
11	....	....	472.36	....	653			
21	....	....	472.50	....	679			
31	....	....	472.64	....	705			
Sept. 8	....	....	472.77	....	729			

Increase per d iy, 0s.014. Per day + 26.

1873.

GENERAL RESULTS.

STATIONS.

Martinsburg, W. Va.
Strasburg, Va.
Culpeper, Va.
Charlottesville, Va.
Lynchburg, Va.
Burkeville, Va.
Danville, Va.
Greensborough, N. C.
Salisbury, N. C.
Charlotte, N. C.
Morganton, N. C.
Asheville, N. C.
Knoxville, Tenn.
Williamsburg, Ky.
Rogersville, Tenn.
Bristol, Tenn.
Mount Airy, Va.
Christiansburg, Va.
Natural Bridge, Va.
Covington, Va.
Staunton, Va.
Harrisonburg, Va.

Chief of party, F. E. HILGARD.

Observers, F. E. HILGARD, J. M. POOLE.

GENERAL RESULTS.

MAGNETIC SURVEY, 1873.

MARTINSBURG, W. VA.

Date.	Declination.	Dip.	Time of 120 vibrations. At —.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1873.	° ′	° ′	s.	s.	
July 10	2 50.5 W.	71 27.9	477.93		
	2 53.0 W.	20.5	477.93	471.79	
		35.2	478.76		
		71 16.9			
Means.	2 51.7 W.	71 25.1	478.20	....	4.231

General Results—Continued.

STRASBURG, VA.

Date.	Declination.	Dip.	Time of 120 vibrations.		Horizontal intensity.
			At —.	At Washington.	
1873.	° ′	° ′	s.	s.	
July 12	2 10.4 W.	70 54.8	472.41		
	2 22.4 W.	60.8	470.90		
		55.7	469.52	471.93	
		70 53.6	470.55		
Means.	2 16.4 W.	70 56.2	470.84	....	4.375

CULPEPER, VA.

July 14	2 21.1 W.	70 42.7	465.63		
		40.0	463.80		
		41.8	463.04	471.93	
		70 43.5			
Means.	2 21.1 W.	70 42.0	464.16	....	4.492

CHARLOTTESVILLE, VA.

July 16	1 17.3 W.	70 23.9	469.41		
	1 16.8 W.	17.6	469.22		
		18.8	464.54	471.93	
		70 19.5	466.91		
Means.	1 17.0 W.	70 20.0	467.52	....	4.428

LYNCHBURG, VA.

July 20	0 38.1 W.	69 44.6	456.90		
	0 29.3 W.	45.0	456.40		
		46.4	455.83		
		69 45.1	456.54	472.07	
			457.23		
			456.25		
Means.	0 33.7 W.	69 45.3	456.52	....	4.646

BURKEVILLE, VA.

July 23	1 55.9 W.	69 20.7	458.02		
	2 03.4 W.	20.2	458.67		
		20.7	458.50	472.07	
		69 20.2	458.31		
Means.	1 59.7 W.	69 20.4	458.37	....	4.609

DANVILLE, VA.

July 26	1 14.9 W.	68 53.2	453.33		
	1 17.8 W.	56.6	451.36		
		52.8	452.46	472.07	
		68 56.6	453.48		
Means.	1 16.3 W.	68 54.8	452.66	....	4.727

GREENSBOROUGH, N. C.

July 28	0 45.5 E.	68 37.4	444.11		
	0 40.5 E.	34.4	444.51		
		35.0	444.47	472.07	
		68 34.4	444.87		
			444.86		
Means.	0 43.0 E.	68 35.3	444.56	....	4.901

General Results—Continued.

SALISBURY, N. C.

Date.	Declination.	Dip.	Time of 120 vibrations.		Horizontal intensity.
			At —.	At Washington.	
1873.	° ′	° ′	s.	s.	
July 30	0 53.4 E.	67 44.2	439.19		
	0 50.9 E.	47.0	438.77		
		45.6	439.82	472.07	
		67 47.1			
Means.	0 52.1 E.	67 46.0	439.26	....	5.021

CHARLOTTE, N. C.

Aug. 1	1 00.9 E.	67 08.3	434.08		
	1 06.9 E.	07.3	435.05		
		07.1	437.72	472.22	
		67 07.2	438.48		
Means.	1 03.9 E.	67 07.5	436.33	....	5.089

MORGANTON, N. C.

Aug. 5	1 02.5 E.	67 14.4	437.48		
	1 19.5 E.	14.6	438.18		
		16.0	437.04	472.22	
		67 16.2	436.65		
Means.	1 11.0 E.	67 15.3	437.34	....	5.067

ASHEVILLE, N. C.

Aug. 7	1 58.2 E.	67 29.1	436.88		
		24.6	438.33		
		27.7	436.15	472.22	
		67 25.6	436.21		
Means.	1 58.2 E.	67 26.7	436.89	....	5.078

KNOXVILLE, TENN.

Aug. 11	1 50.6 E.	66 55.6	436.78		
	1 54.6 E.	54.3	437.56		
		56.1	435.76	472.36	
		66 55.4	437.02		
Means	1 52.6 E.	66 55.3	436.78	....	5.093

WILLIAMSBURG, KY.

Aug. 14	2 01.8 E.	68 20.8	443.12		
	2 06.3 E.	27.2	443.88		
		29.9	443.38	472.36	
		68 25.1	442.94		
Means.	2 04.0 E.	68 25.7	443.33	....	4.933

ROGERSVILLE, TENN.

Aug. 18	1 47.5 E.	68 26.1	440.55		
	1 50.5 E.	26.3	440.74		
		25.6	441.78	472.36	
		68 26.9	441.68		
Means.	1 49.0 E.	68 26.2	441.19	....	4.982

General Results—Continued.

BRISTOL, TENN.

Date.	Declination	Dip.	Time of 120 vibrations. At —.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1873.	° ′	° ′	s.	s.	
Aug. 20	1 18.5 E.	68 12.9	444.47		
	1 20.5 E.	10.2	443.96		
		11.2	446.37	472.50	
		68 09.9	444.86		
Means.	1 19.5 E.	68 11.0	444.91	....	4.900

MOUNT AIRY, VA.

Date.	Declination	Dip.	At —.	At Washington.	Horizontal intensity.
Aug. 21	0 57.2 E.	68 55.6	452.13		
	0 53.2 E.	54.1	448.34		
		55.1	449.11	472.50	
		68 54.0	449.93		
Means.	0 55.2 E.	68 54.7	449.88	....	4.793

CHRISTIANSBURG, VA.

Date.	Declination	Dip.	At —.	At Washington.	Horizontal intensity.
Aug. 23	0 32.0 E.	69 00.5	452.85		
	0 37.0 E.	01.7	452.54		
		01.0	452.66	472.50	
		69 01.1	454.74		
			454.78		
Means.	0 34.5 E.	69 01.1	453.51	....	4.717

NATURAL BRIDGE, VA.

Date.	Declination	Dip.	At —.	At Washington.	Horizontal intensity.
Aug. 26	0 07.0 W.	69 42.5	458.78		
	0 02.5 W.	42.2	459.57		
		43.7	460.09	472.50	
		69 43.2	458.72		
			458.72		
Means.	0 04.7 W.	69 42.9	459.18	....	4.602

COVINGTON, VA.

Date.	Declination	Dip.	At —.	At Washington.	Horizontal intensity.
Aug. 30	0 24.9 W.	69 47.7	458.28		
	0 19.4 W.	47.0	457.91		
		47.7	461.88	472.64	
		69 46.8	462.55		
Means.	0 22.1 W.	69 47.3	460.15	....	4.584

STAUNTON, VA.

Date.	Declination	Dip.	At —.	At Washington.	Horizontal intensity.
Sept. 1	0 47.9 W.	69 56.2	465.25		
	0 43.4 W.	55.3	465.55		
		49.6	464.48	472.64	
		69 55.1	464.58		
Means.	0 45.6 W.	69 54.1	464.96	....	4.489

HARRISONBURG, VA.

Date.	Declination	Dip.	At —.	At Washington.	Horizontal intensity.
Sept. 2	1 26.0 W.	70 30.2	469.82		
	1 30.0 W.	28.2	469.76		
		29.5	465.06	472.64	
		70 27.9	466.10		
Means.	1 28.0 W.	70 28.9	467.68	....	4.437

1874.

DESCRIPTIONS OF STATIONS.

YORK, PA.—The station was established in a field belonging to Mr. Small, hardware dealer in York. It is on the west bank of the river, between the first two of the three trees in the lot. The mark was the west corner of the cemetery chapel chimney. The character of the country is unfavorable, there being much iron ore.

ALTOONA, PA.—The station is in a field belonging to the Pennsylvania Railroad Company, and may be found by applying to Mr. Dixon, the farmer. The mark was the east lightning-rod of the house on the hill.

WILLIAMSPORT, PA.—The station is in a field belonging to Mr. Herdic, west of Mr. Woodward's house. Meridian marked for county surveyor, who will endeavor to preserve it. The mark was the white steeple in Newberry.

BATH, N. Y.—In consequence of buildings, the station occupied in 1841 by Professor Bache could not be reoccupied. The station selected by me is in a field belonging to Judge Rumsey, and is marked by an oak stake. The mark used is the ball on the Methodist church. There are two oak trees in the field close together. The station is 30 paces west of them.

ROCHESTER, N. Y.—The station was established on the campus of the university, and marked by a stub. It is on the grass plat southeast of the college near the ball grounds. It is 55 paces from the fifth tree of the east carriage road, and 31 paces south of the first tree on the path leading east from the building. The dip was taken under this tree. The mark was the southeast corner of the southeast chimney of the main building. A true meridian was given.

NIAGARA FALLS, N. Y.—The station is in a lot belonging to G. W. Holley, adjoining his place. It is 20 paces west of the only tree in the lot, and 18 paces northeast of a hole dug in search for gold. The mark was the cross on the steeple of the Catholic church. The azimuth station was on the line between the mark and the station, 15 paces from station and 10 feet east of west fence.

MAYVILLE, CHAUTAUQUA COUNTY, NEW YORK.—The station is marked by a peg in the grounds of the public school on the hill. It is between four trees near the south fence. The mark was the cupola of the school. The azimuth station is 50 feet from the magnetic station, in the line between it and the mark. A true north line was given.

SHARPSVILLE, MERCER COUNTY, PENNSYLVANIA.—[No description given.]

BEAVER, BEAVER COUNTY, PENNSYLVANIA.—The station is in a field belonging to Mr. De Vaux, near the river. The mark is the spire of the Methodist church.

GREENFIELD, PA. (formerly occupied as Brownsville), near Johnston's tavern. The station is in a field of Mr. Gregg. The mark is the Presbyterian church spire in Greenfield.

TUSCARAWAS, OHIO.—This is Trenton Station on the railroad. The station was established in a field of Mr. J. Blickensderfer. The mark is the south side of the cupola of the Moravian church.

COLUMBUS, OHIO.—The station is in the grounds of the Blind Asylum. The mark is the north cupola of the asylum.

FOREST, OHIO.—The station was in the woods south of the town. The mark was the west church in the town.

FORT WAYNE, IND.—The station is in the Fair Grounds, in the western part of town, under the tree nearest the half-mile race course. The mark is the tombstone on the hill southeast of station.

REYNOLDS, IND.—The station was made in a field of Mr. Van Voerst. The mark is the point of the Presbyterian church.

TERRE HAUTE, IND.—The station is in a field in the prolongation of Fourth street, belonging to Mr. Whitaker. The mark is the cupola on a house to southeast.

1874.

OBSERVATIONS FOR DECLINATION.

STATIONS.

York, Pa.	Rochester, N. Y.	Beaver, Pa.	Forest, Ohio.
Altoona, Pa.	Niagara Falls, N. Y.	Greenfield, Pa.	Fort Wayne, Ind.
Williamsport, Pa.	Mayville, N. Y.	Tuscarawas, Ohio.	Reynolds, Ind.
Bath, N. Y.	Sharpsville, Pa.	Columbus, Ohio.	Terre Haute, Ind.

Observer, F. E. HILGARD.

The following table was used in reducing the observed magnetic meridian to the mean of day:

Time of day.	Correction.	Time of day.	Correction.
h. m.	′	*h. m.*	′
6.00 a. m.	−3.0	0.00 p. m.	+4.5
6.30 a. m.	−3.7	0.30 p. m.	+5.0
7.00 a. m.	−4.5	1.00 p. m.	+6.0
7.30 a. m.	−5.0	1.30 p. m.	+6.0
8.00 a. m.	−6.0	2.00 p. m.	+5.0
8.30 a. m.	−6.0	2.30 p. m.	+4.5
9.00 a. m.	−5.0	3.00 p. m.	+3.0
		4.00 p. m.	+1.5
		5.00 p. m.	+0.0
		6.00 p. m.	+0.0

These corrections are to be applied to the reading of the observed magnetic meridian.

For explanation of significance of the various columns, see note preceding declination observations, 1871–'72.

OBSERVATIONS FOR DECLINATION.

MAGNETIC SURVEY, 1874.

YORK, PA. $\phi=39° 58'$.

Date.		Obs'd altitude.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of ob'ns for declination.
1874.		° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
July 23, a.m.	ȸ	21 01.0	81 04.9	94 18.2	13 13.3	339 34.0	326 20.7	....	330 18.0	3 56.3	W.	July 13, a.m.
23, a.m.	ȸ	23 10.0	82 46.8	95 58.1	13 11.3	339 34.0	326 22.7	326 21.7	330 21.0	3 59.3	W.	13, p.m.
										3 57.8	W.	
ALTOONA, PA.* $\phi=40° 30'.6$.												
July 15, p.m.	ɸ	17 54.6	283 31.1	286 12.4	2 41.3	269 41.0	266 59.7					
15, p.m.	ɸ	14 26.0	286 20.6	289 05.3	2 44.7	269 41.0	266 56.3	266 58.0	273 56.0	2 47.0	W.	July 16, a.m.
								+ 4 11.0				
								*271 09.0				

*Azimuth determined at eccentric station. Reduction to azimuth "magnetometer to mark" = +4° 11′.

Observations for Declination—Continued.

Date.		Obs'd altitude.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
WILLIAMSPORT, PA. $\phi=41° 15'$.												
1874.		° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
July 18, p.m.	$\overline{\odot}$	19 00.5	281 50.6	106 22.6	184 32.0	77 25.0	252 53.0	....	257 45.0	4 50.9	W.	July 18, p.m.
18, p.m.	$\overline{\odot}$	15 29.5	284 46.2	109 16.8	184 30.6	77 25.0	252 54.4	....	257 47.0	4 52.9	W.	20, a.m.
20, a.m.	$\underline{\odot}$	22 13.8	81 38.1	8 43.3	287 05.2	180 00.0	252 54.8	....	257 41.0	4 46.9	W.	20, p.m.
20, a.m.	$\underline{\odot}$	25 19.3	84 12.1	11 18.0	287 05.9	180 00.0	252 54.1	252 54.1				
										4 50.2	W.	
BATH, N. Y. $\phi=42° 21'.5$.												
July 24, p.m.	$\overline{\odot}$	26 35.5	273 27.5	161 30.8	248 03.3	180 00.0	291 56.7					
24, p.m.	$\overline{\odot}$	24 30.7	275 18.1	163 21.7	248 03.6	180 00.0	291 56.4					
25, a.m.	$\underline{\odot}$	24 24.8	85 15.7	333 16.0	248 00.3	180 00.0	291 59.7	....	297 30.4	5 32.2	W.	July 24, p.m.
25, a.m.	$\underline{\odot}$	26 47.8	87 22.1	335 21.9	247 59.8	180 00.0	292 00.2	291 58.2	297 34.9	5 36.7	W.	25, a.m.
										5 34.4	W.	
ROCHESTER, N. Y. $\phi=43° 08'$.												
July 29, p.m.	$\overline{\odot}$	26 36.6	271 27.7	101 37.2	190 09.5	180 00.0	349 50.5					
29, p.m.	$\overline{\odot}$	24 17.5	273 35.2	103 48.0	190 12.8	180 00.0	349 47.2	....	255 08.3	5 21.1	W.	July 29, p.m.
29, p.m.	$\overline{\odot}$	21 40.1	275 57.6	106 13.6	190 16.0	180 00.0	349 44.0	349 47.2	255 01.8	5 14.6	W.	30, a.m.
										5 17.8	W.	
NIAGARA FALLS, N. Y. $\phi=43° 04'$.												
July 31, p.m.	$\overline{\odot}$	32 35.1	265 04.1	128 03.1	222 59.0	180 00.0	317 01.0					
31, p.m.	$\overline{\odot}$	24 47.0	272 28.1	135 28.5	223 00.4	180 00.0	316 59.6	....	320 32.8	3 32.9	W.	July 31, p.m.
31, p.m.	$\overline{\odot}$	23 28.8	273 39.2	136 40.0	223 00.8	180 00.0	316 59.2	316 59.9	320 41.3	3 41.4	W.	Aug. 1, a.m.
										3 37.1	W.	
MAYVILLE, N. Y. $\phi=42° 16'$.												
Aug. 4, a.m.	$\underline{\odot}$	20 03.0	84 45.8	294 28.0	209 42.2	180 00.0	330 17.8					
4, a.m.	$\underline{\odot}$	22 37.5	87 02.7	296 46.2	209 43.5	180 00.0	330 16.5					
4, p.m.	$\overline{\odot}$	23 36.2	272 23.2	122 07.0	209 43.8	180 00.0	330 16.2	330 16.8	332 31.8	2 15.0	W.	Aug. 4.
SHARPSVILLE, PA., FIRST STATION. $\phi=41° 17'$.												
Aug. 6, p.m.	$\overline{\odot}$	30 04.7	266 16.7	10 14.1	103 57.4	180 00.0	76 02.6					
6, p.m.	$\overline{\odot}$	26 55.1	269 07.6	13 05.6	103 58.0	180 00.0	76 02.0					
6, p.m.	$\overline{\odot}$	23 09.5	272 24.5	16 21.6	103 57.1	180 00.0	76 02.9	76 02.5	77 02.5	1 00.0	W.	Aug. 6, p.m.
SHARPSVILLE, PA., SECOND STATION.												
Aug. 7, p.m.	$\overline{\odot}$	21 10.6	273 42.1	149 42.1	236 00.0	180 00.0	304 00.0					
7, p.m.	$\overline{\odot}$	18 00.2	276 25.0	152 26.2	236 01.2	180 00.0	303 58.8	....	303 51.0	0 07.2	E.	Aug. 7, p.m.
7, p.m.	$\overline{\odot}$	14 56.1	279 02.0	155 06.1	236 04.1	180 00.0	303 55.9	303 58.2	303 45.3	0 12.9	E.	8, a.m.
										0 10.0	E.	
BEAVER, PA. $\phi=40° 43'.5$.												
Aug. 11, a.m.	$\overline{\odot}$	31 31.9	96 41.0	245 08.0	148 27.0	180 00.0	31 33.0					
11, a.m.	$\overline{\odot}$	32 44.4	97 50.0	246 14.0	148 24.0	180 00.0	31 36.0					
11, a.m.	$\overline{\odot}$	33 46.3	98 50.0	247 15.1	148 25.1	180 00.0	31 34.9					
11, p.m.	$\overline{\odot}$	25 46.1	268 29.0	56 54.5	148 25.5	180 00.0	31 34.5					
11, p.m.	$\overline{\odot}$	23 10.7	270 36.2	59 03.8	148 27.6	180 00.0	31 32.4					
11, p.m.	$\overline{\odot}$	19 55.2	273 22.3	61 50.9	148 28.6	180 00.0	31 31.4	31 33.7	32 41.9	1 08.2	W.	Aug. 11.

Observations for Declination—Continued.

GREENFIELD, PA. $\phi=40^\circ\ 06'$.

Date.		Obs'd altitude.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
1874.		° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
Aug. 13, p.m.	φ	30 30.0	263 39.7	94 25.2	190 45.5	180 00.0	349 14.5					
13, p.m.	φ	29 46.5	264 19.2	95 02.7	190 43.5	180 00.0	349 16.5					
13, p.m.	φ	24 20.1	269 04.2	99 50.0	190 45.8	180 00.0	349 14.2					
13, p.m.	φ	23 08.5	270 04.6	100 49.0	190 44.4	180 00.0	349 15.6	....	351 22.0	2 06.5	W.	Aug. 13, p.m.
14, a.m.	ȸ	30 54.1	97 29.8	288 09.9	190 40.1	179 57.0	349 16.9	349 15.5	351 13.4	1 57.9	W.	14, a.m.
										2 02.2	W.	

TUSCARAWAS, OHIO. $\phi=40^\circ\ 24'.2$.

Date.		Obs'd altitude.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 17, p.m.	φ	28 32.5	263 23.9	146 38.5	243 14.6	180 00.0	296 45.4					
17, p.m.	φ	26 52.6	264 54.6	148 08.4	243 13.8	180 00.0	296 46.2					
17, p.m.	φ	24 21.1	267 08.9	150 25.4	243 16.5	180 00.0	296 43.5					
17, p.m.	φ	18 13.0	272 23.0	155 39.8	243 16.6	180 00.0	296 43.2					
18, a.m.	ȸ	14 28.6	85 08.7	328 25.0	243 16.3	180 00.0	296 43.7	....	296 58.9	0 14.6	W.	Aug. 17, p.m.
18, a.m.	ȸ	16 58.7	87 14.7	330 30.7	243 16.0	180 00.0	296 44.0	296 44.3	297 09.1	0 24.8	W.	18, a.m.
										0 19.7	W.	

COLUMBUS, OHIO. $\phi=39^\circ\ 57'$.

Date.		Obs'd altitude.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 19, p.m.	φ	30 11.2	261 12.9	54 50.7	153 37.8	180 00.0	26 22.2					
19, p.m.	φ	28 57.2	262 21.6	55 59.6	153 38.0	180 00.0	26 22.0	26 22.1	25 10.0	1 12.1	E.	Aug. 19, p.m.

FOREST, OHIO. $\phi=40^\circ\ 50'$.

Date.		Obs'd altitude.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 21, a.m.	ȸ	23 39.0	94 34.7	353 18.7	258 44.0	180 00.0	281 16.0					
21, a.m.	ȸ	26 10.0	96 53.2	355 37.7	258 44.5	180 00.0	281 15.5					
21, p.m.	φ	32 16.7	257 30.9	156 16.0	258 45.1	180 00.0	281 14.9					
21, p.m.	φ	30 47.6	258 59.3	157 47.2	258 47.9	180 00.0	281 12.1	281 14.6	278 56.3	2 18.3	E.	Aug. 21.

FORT WAYNE, IND. $\phi=41^\circ\ 06'.3$.

Date.		Obs'd altitude.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 21, a.m.	ȸ	14 50.5	88 18.2	120 31.6	32 13.4	180 00.0	147 46.6					
21, a.m.	ȸ	16 22.5	89 38.4	121 52.2	32 13.8	180 00.0	147 46.2	....	145 12.6	2 33.9	E.	Aug. 24, a.m.
21, a.m.	ȸ	19 00.5	91 57.4	124 10.7	32 13.3	180 00.0	147 46.7	147 46.5	145 22.2	2 24.3	E.	24, p.m.
										2 29.1	E.	

REYNOLDS, IND. $\phi=40^\circ\ 45'$.

Date.		Obs'd altitude.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 27, a.m.	ȸ	20 46.2	94 50.3	243 25.4	148 35.1	180 00.0	31 24.9					
27, a.m.	ȸ	22 17.1	96 12.7	244 47.3	148 34.6	180 00.0	31 25.4	....	28 00.0	3 25.2	E.	Aug. 26, p.m.
27, a.m.	ȸ	24 32.7	98 18.2	246 53.0	148 34.8	180 00.0	31 25.2	31 25.2	27 49.8	3 35.4	E.	27, a.m.
										3 30.3	E.	

TERRE HAUTE, IND. $\phi=39^\circ\ 28'$.

Date.		Obs'd altitude.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	<Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 31, a.m.	ȸ	24 34.0	99 07.4	138 07.4	39 00.0	180 00.0	141 00.0					
31, a.m.	ȸ	27 40.8	102 31.2	141 32.0	39 00.8	180 00.0	140 59.2	....	136 30.0	4 29.1	E.	Aug. 28, p.m.
31, a.m.	ȸ	31 00.0	105 49.2	144 51.1	39 01.9	180 00.0	140 58.1	140 59.1	136 19.7	4 39.4	E.	29, a.m.
										4 34.2	E.	

1874.

OBSERVATIONS FOR LOCAL TIME.

STATIONS.

York, Pa.
Altoona, Pa.
Williamsport, Pa.
Bath, N. Y.
Rochester, N. Y.
Niagara Falls, N. Y.
Mayville, N. Y.
Sharpsville, Pa.
Beaver, Pa.
Greenfield, Pa.
Tuscarawas, Ohio.
Columbus, Ohio.
Forest, Ohio.
Fort Wayne, Ind.
Reynolds, Ind.

Observer, F. E. HILGARD.

OBSERVATIONS FOR LOCAL TIME.

MAGNETIC SURVEY, 1874.

YORK, PA. $\phi = 39° 58'$.

Date.		Obs'd altitude.	Mean time of obs'n.	Time by chronometer.	Chronometer fast.
1874.		° ′	*h. m. s.*	*h. m. s.*	*m. s.*
July 23, a. m.	$\underline{\odot}$	21 01.0	6 51 36	6 51 34.0	− 0 02.0
23, a. m.	$\underline{\odot}$	23 10.0	7 02 54	7 02 50.0	− 0 04.0

ALTOONA, PA. $\phi = 40° 30'.6$.

July 15, p. m.	$\overline{\odot}$	17 54.6	5 44 40.9	5 49 22.3	+ 4 41.4
15, p. m.	$\overline{\odot}$	14 26.0	6 03 40.9	6 09 11.0	4 30.1

WILLIAMSPORT, PA. $\phi = 41° 15'$.

July 18, p. m.	$\overline{\odot}$	19 00.5	5 38 09.9	5 38 42.1	0 32.2
18, p. m.	$\overline{\odot}$	15 29.5	5 57 27.5	5 [illegible]8 00.0	0 32.5
20, a. m.	$\underline{\odot}$	22 13.8	6 55 00.9	6 55 31.3	0 30.4
20, a. m.	$\underline{\odot}$	25 19.3	7 11 37.5	7 12 02.3	0 24.8

BATH, N. Y. $\phi = 42° 21'.5$.

July 24, p. m.	$\overline{\odot}$	26 35.5	4 54 09.7	4 56 37.5	2 27.8
24, p. m.	$\overline{\odot}$	24 30.7	5 05 28.8	5 08 06.6	2 37.8
25, a. m.	$\underline{\odot}$	24 24.8	7 09 42.2	7 12 20.7	2 38.5
25, a. m.	$\underline{\odot}$	26 47.8	7 22 30.0	7 25 07.3	2 28.3

ROCHESTER, N. Y. $\phi = 43° 08'$.

July 29, p. m.	$\overline{\odot}$	26 36.6	4 50 18.8	5 01 27.8	11 09.0
29, p. m.	$\overline{\odot}$	24 17.5	5 03 01.7	5 14 15.2	11 13.5
29, p. m.	$\overline{\odot}$	21 40.1	5 17 28.5	5 28 43.0	11 14.5

NIAGARA FALLS, N. Y. $\phi = 43° 04'$.

July 31, p. m.	$\overline{\odot}$	32 35.1	4 15 44.0	4 32 55.7	17 11.7
31, p. m.	$\overline{\odot}$	24 47.0	4 58 30.4	5 15 49.3	17 18.9
31, p. m.	$\overline{\odot}$	23 28.8	5 05 39.5	5 22 58.0	17 18.5

MAYVILLE, N. Y. $\phi = 42° 16'$.

Aug. 4, a. m.	$\underline{\odot}$	20 03.0	6 53 52.9	7 13 29.0	19 36.1
4, a. m.	$\underline{\odot}$	22 37.5	7 07 50.6	7 27 30.0	19 39.4
4, p. m.	$\overline{\odot}$	23 36.2	5 00 55.2	5 20 29.7	19 34.5

SHARPSVILLE, PA. $\phi = 41° 17'$.

Aug. 6, p. m.	$\overline{\odot}$	30 04.7	4 24.08.7	4 48 32.0	24 23.3
6, p. m.	$\overline{\odot}$	26 55.1	4 40 58.9	5 05 32.0	24 33.1

Observations for Local Time—Continued.

BEAVER, PA. $\phi=40° 43'.5$.

Date.		Obs'd altitude.	Mean time of obs'n.	Time by chronometer.	Chronometer fast.
1874.		° ′	h. m. s.	h. m. s.	m. s.
Aug. 11, a. m.	$\underline{\odot}$	31 31.9	7 58 21.3	8 22 28.5	24 07.2
11, a. m.	$\underline{\odot}$	32 44.4	8 04 42.6	8 28 43.1	24 00.5
11, a. m.	$\underline{\odot}$	33 46.3	8 10 18.0	8 34 20.7	24 02.7
11, p. m.	$\underline{\odot}$	25 46.1	4 41 41.3	5 05 41.5	24 00.2
11, p. m.	$\underline{\odot}$	23 10.7	4 55 22.3	5 19 23.5	24 01.2
11, p. m.	$\underline{\odot}$	19 55.2	5 12 37.4	5 36 38.2	24 00.8

GREENFIELD, PA. $\phi=40° 06'$.

Aug. 13, p. m.	$\underline{\odot}$	30 30.0	4 14 43.3	4 24 38.1	9 54.8
13, p. m.	$\underline{\odot}$	29 46.5	4 18 32.9	4 28 24.1	9 51.2
13, p. m.	$\underline{\odot}$	24 20.1	4 47 03.2	4 56 47.6	9 44.4
13, p. m.	$\underline{\odot}$	23 08.5	4 53 18.2	5 03 03.5	9 45.3
14, a. m.	$\overline{\odot}$	30 54.1	7 59 52.1	8 09 51.5	9 59.4

TUSCARAWAS, OHIO. $\phi=40° 24'.2$.

Aug. 17, p. m.	$\underline{\odot}$	28 32.5	4 19 55.4	4 36 05.0	16 09.6
17, p. m.	$\underline{\odot}$	26 52.6	4 28 43.9	4 44 51.0	16 07.1
17, p. m.	$\underline{\odot}$	24 21.1	4 42 01.5	4 58 09.0	16 07.5
17, p. m.	$\underline{\odot}$	18 13.0	4 14 17.5	5 30 23.0	16 05.5
18, a. m.	$\overline{\odot}$	14 28.6	6 36 36.7	6 52 55.5	16 18.8
18, a. m.	$\overline{\odot}$	16 58.7	6 49 52.7	7 06 07.1	16 14.4

COLUMBUS, OHIO. $\phi=39° 57'$.

Aug. 19, p. m.	$\underline{\odot}$	30 11.2	4 08 55.6	4 31 41.1	22 45.5
19, p. m.	$\underline{\odot}$	28 57.2	4 15 26.0	4 38 09.7	22 43.7

FOREST, OHIO. $\phi=40° 50'$.

Aug. 21, a. m.	$\overline{\odot}$	26 10.0	7 41 14.5	8 06 03.0	24 48.5
21, p. m.	$\underline{\odot}$	32 16.7	3 54 05.7	4 18 56.0	24 50.3
21, p. m.	$\underline{\odot}$	30 47.6	4 02 07.3	4 27 03.8	24 56.5

FORT WAYNE, IND. $\phi=41° 06'.3$.

Aug. 21, a. m.	$\overline{\odot}$	14 50.5	6 43 42.6	7 15 22.0	31 39.4
21, a. m.	$\overline{\odot}$	16 22.5	6 51 53.2	7 23 37.5	31 44.3
21, a. m.	$\overline{\odot}$	19 00.5	7 05 54.2	7 37 35.6	31 41.4

REYNOLDS, IND. $\phi=40° 45'$.

Aug. 27, a. m.	$\overline{\odot}$	20 46.2	7 17 54.2	7 56 32.0	38 37.8
27, a. m.	$\overline{\odot}$	22 17.1	7 25 57.4	8 04 30.4	38 33.0
27, a. m.	$\overline{\odot}$	24 32.7	7 38 00.4	8 16 45.0	38 44.6

1874.

OBSERVATIONS FOR DIP.

STATIONS.

York, Pa.
Altoona, Pa.
Williamsport, Pa.
Bath, N. Y.
Rochester, N. Y.
Niagara Falls, N. Y.
Mayville, N. Y.
Sharpsville, Pa.
Beaver, Pa.
Greenfield, Pa.
Tuscarawas, Ohio.
Columbus, Ohio.
Forest, Ohio.
Fort Wayne, Ind.
Reynolds, Ind.
Terre Haute, Ind.

Observer, W. DIEHL.

MAGNETIC SURVEY, 1874.

YORK, PA.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
1874.		° ′	′	′	° ′	′	′	° ′
July 11, a. m.	1	71 54.7	35.5	45.1	71 26.1	79.7	52.9	71 49.0
11, p. m.	1	71 77.1	32.5	54.8	71 44.0	75.6	59.8	71 57.3
11, a. m.	2	71 63.1	45.0	54.0	71 34.3	69.1	51.5	71 52.7
11, p. m.	2	71 78.8	29.1	53.9	71 42.8	63.6	53.2	71 53.5
								71 53.1
13, a. m.	1	71 71.8	38.1	54.9	71 42.4	71.3	56.8	71 55.8
13, p. m.	1	71 68.6	29.2	53.9	71 40.3	66.7	53.5	71 53.7
13, a. m.	2	71 86.3	27.9	57.1	71 41.3	63.0	53.6	71 55.3
13, p. m.	2	71 67.1	37.6	52.3	71 53.7	77.7	65.7	71 59.0
								71 55.9

ALTOONA, PA.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
July 16, p. m.	1	72 22.1	17.1	19.6	72 02.7	43.5	23.1	72 21.4
17, a. m.	1	72 30.8	04.7	17.7	72 08.3	40.7	24.5	72 21.1
16, p. m.	2	72 42.1	08.1	25.1	72 04.6	25.4	15.0	72 20.0
17, a. m.	2	72 29.3	30.0	29.6	72 09.5	28.4	18.9	72 24.2
								72 21.7

WILLIAMSPORT, PA.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
July 18, p. m.	1	72 58.1	35.1	46.6	72 34.7	74.7	54.7	72 50.6
20, a. m.	1	72 60.0	30.5	45.2	72 34.0	64.7	49.3	72 47.2
18, p. m.	2	72 77.6	32.2	54.9	72 31.8	55.6	43.7	72 49.3
20, a. m.	2	72 57.7	28.3	43.0	72 23.5	62.1	42.8	72 42.9
								72 47.5

BATH, N. Y.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
July 24, a. m.	1	74 35.4	00.8	18.1	74 05.6	35.6	20.6	74 19.3
24, p. m.	1	74 25.6	54.7	10.1	74 01.5	24.2	12.8	74 11.4
24, a. m.	2	74 28.9	02.7	15.8	73 56.6	85.1	70.8	74 13.3
24, p. m.	2	74 38.2	19.7	28.9	73 54.3	80.7	67.5	74 18.2
								74 15.55

ROCHESTER, N. Y.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
July 29, p. m.	1	74 63.5	17.6	40.5	74 42.7	60.3	52.8	74 46.7
30, a. m.	1	74 57.8	16.7	37.2	74 22.1	58.2	40.1	74 38.6
29, p. m.	2	74 56.5	18.7	37.6	74 14.8	59.6	37.3	74 37.4
30, a. m.	2	74 52.6	18.5	35.5	74 12.7	41.5	27.1	74 31.3
								74 38.5

Observations for Dip—Continued.

NIAGARA FALLS, N. Y.

Date.	Needle.	Polarity N. Circle E.	Polarity N. W.	Mean.	Polarity S. Circle W.	Polarity S. E.	Mean.	Dip.
1874.		° ′	′	′	° ′	′	′	° ′
July 31, p. m.	1	74 55.3	14.0	34.6	74 21.2	59.5	40.3	74 37.4
Aug. 1, a. m.	1	74 49.2	19.9	34.5	74 25.0	63.7	44.3	74 39.4
July 31, p. m.	2	74 45.1	25.9	35.5	74 16.8	55.5	36.1	74 35.8
Aug. 1, a. m.	2	74 56.8	20.3	38.5	74 18.2	57.8	38.0	74 38.2
								74 37.7

MAYVILLE, N. Y.

Date.	Needle.	Polarity N. Circle E.	Polarity N. W.	Mean.	Polarity S. Circle W.	Polarity S. E.	Mean.	Dip.
Aug. 4, p. m.	1	73 93.2	37.8	65.5	73 43.6	86.2	64.9	74 05.2
4, a. m.	1	73 80.5	49.3	64.9	73 51.6	79.5	65.5	74 05.2
4, p. m.	2	73 71.0	43.2	57.1	73 51.8	80.2	66.0	74 01.5
4, a. m.	2	73 96.0	39.5	67.7	73 51.0	85.8	68.4	74 08.0
								74 05.0

SHARPSVILLE, PA.

Date.	Needle.	Polarity N. Circle E.	Polarity N. W.	Mean.	Polarity S. Circle W.	Polarity S. E.	Mean.	Dip.
Aug. 6, p m.	1	72 73.0	27.4	50.2	72 41.7	68.5	55.1	72 52.6
7, a. m.	1	72 58.4	36.2	47.3	72 38.1	68.8	53.4	72 50.3
6, p. m.	2	72 66.0	29.1	47.6	72 29.3	71.5	50.4	72 49.0
7, a. m.	2	72 66.9	33.2	50.0	72 32.6	71.5	52.0	72 51.0
								72 50.7

BEAVER, PA.

Date.	Needle.	Polarity N. Circle E.	Polarity N. W.	Mean.	Polarity S. Circle W.	Polarity S. E.	Mean.	Dip.
Aug. 11, a. m.	1	72 43.5	21.2	32.3	72 13.7	51.7	32 7	72 32.5
11, p. m.	1	72 40.7	15.5	28.1	72 12.7	49.5	31.1	72 29.6
11, a. m.	2	72 42.7	16.5	29.6	72 21.0	51.2	36.1	72 32.8
11, p. m.	2	72 48.1	10.2	29.1	72 10.5	55.8	33.1	72 31.1
								72 31.5

GREENFIELD, PA.

Date.	Needle.	Polarity N. Circle E.	Polarity N. W.	Mean.	Polarity S. Circle W.	Polarity S. E.	Mean.	Dip.
Aug. 13, p. m.	1	71 76.5	46.5	61.5	71 45.8	75.0	60.4	71 60.9
14, a. m.	1	71 71.5	39.0	55.2	71 37.2	79.5	58.3	71 56.7
13, p. m.	2	71 70.0	37.0	53.5	71 47.0	81.2	64.1	71 58.8
14, a. m.	2	71 76.5	37.5	57.0	71 44.0	79.7	61.8	71 59.4
								71 58.9

TUSCARAWAS, OHIO.

Date.	Needle.	Polarity N. Circle E.	Polarity N. W.	Mean.	Polarity S. Circle W.	Polarity S. E.	Mean.	Dip.
Aug. 17, a. m.	1	71 80.8	52.5	66.7	71 54.5	88.2	71.3	72 09.0
17, p. m.	1	71 78.2	59.7	68.9	71 59.3	86.9	73.1	72 11.0
17, a. m.	2	71 81.8	46.5	64.1	71 58.7	85.6	72.1	72 08.1
17, p. m.	2	71 80.7	43.8	62.3	71 52.3	87.6	69.9	72 06.1
								72 08.5

COLUMBUS, OHIO.

Date.	Needle.	Polarity N. Circle E.	Polarity N. W.	Mean.	Polarity S. Circle W.	Polarity S. E.	Mean.	Dip.
Aug. 19, p. m.	1	70 80.0	42.8	61.4	70 45.0	79.0	62.0	71 01.7
19, p. m.	2	70 70.0	39.6	54.8	70 37.2	84.7	60.9	70 57.8
								70 59.7

Observations for Dip—Continued.

FOREST, OHIO.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
1874.		° ′	′	′	° ′	° ′	′	° ′
Aug. 21, a. m.	1	71 92.5	59.8	76.1	71 42.1	73 00.3	81.2	72 18.6
21, p. m.	1	71 89.1	68.5	78.8	71 70.7	95.5	83.1	72 21.0
21, a. m.	2	72 36.6	00.4	18.5	72 06.1	45.5	25.8	72 22.1
21, p. m.	2	72 32.5	06.2	19.3	72 10.0	35.5	22.7	72 21.0
								72 20.7

FORT WAYNE, IND.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
Aug. 24, a. m.	1	72 30.7	08.2	19.4	72 02.5	34.2	18.3	72 18.8
24, p. m.	1	72 30.2	04.5	17.5	72 08.0	39.1	23.5	72 20.5
24, a. m.	2	72 35.2	01.7	18.4	72 01.7	32.5	17.6	72 18.0
24, p. m.	2	72 35.2	53.7	14.4	72 06.7	39.0	22.8	72 18.6
								72 19.0

REYNOLDS, IND.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
Aug. 26, p. m.	1	71 80.7	41.7	61.2	71 44.8	74.5	59.6	72 00.4
27, a. m.	1	71 74.2	44.8	59.5	71 48.7	74.0	61.3	72 01.3
26, p. m.	2	71 76.0	40.7	58.3	71 43.0	73.5	58.2	71 58.3
27, a. m.	2	71 75.2	38.5	56.8	71 48.0	77.7	62.8	71 59.8
								72 00.0

TERRE HAUTE, IND.

Date.	Needle.	Polarity N. Circle E.	W.	Mean.	Polarity S. Circle W.	E.	Mean.	Dip.
Aug. 28, p. m.	1	70 54.1	25.5	39.8	70 25.6	48.8	37.2	70 38.5
29, a. m.	1	70 51.5	20.2	35.8	70 24.0	56.5	40.2	70 38.0
28, p. m.	2	70 44.0	11.0	27.5	70 12.8	47.5	30.1	70 28.8
29, a. m.	2	70 42.8	16.7	29.7	70 26.8	48.2	37.5	70 33.6
								70 34.7

1874.

OBSERVATIONS FOR HORIZONTAL INTENSITY.

STATIONS.

York, Pa.	Rochester, N. Y.	Beaver, Pa.	Forest, Ohio.
Altoona, Pa.	Niagara Falls, N. Y.	Greenfield, Pa.	Fort Wayne, Ind.
Williamsport, Pa.	Mayville, N. Y.	Tuscarawas, Ohio.	Reynolds, Ohio.
Bath, N. Y.	Sharpsville, Pa.	Columbus, Ohio.	Terre Haute, Ind.

Observer, F. E. HILGARD.

WASHINGTON, 1874.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
1874.	h. m.	°	s.	s.	s.	s.		
July 8	4 52	91.0	480.02	2.07	477.95			
8	5 14	90.0	480.07	2.01	478.06			
9	6 18	77.5	479.31	1.17	478.14			
					478.05			
Sept. 9	7 25	63.0	477.17	0.20	476.97			
10	8 25	66.0	477.18	0.40	476.78	477.85	1.000	4.349
10	8 40	69.0	477.50	0.60	476.90			
10	4 18	85.5	480.45	1.70	478.75			
10	4 31	84.5	480.35	1.64	478.71			
					477.66			

Observations for Intensity—Continued.

REDUCTIONS FOR TEMPERATURE.

T.	Reduction for 1°.
s.	*s.*
473	0.066
480	0.067
486	0.068
493	0.069
500	0.070
507	0.071
514	0.072
520	0.073
527	0.074

MAGNETIC SURVEY, 1874.

YORK, PA.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T.		H.	
					Corrected.	Washington.	Relative.	Absolute.
1874.	*h. m.*	°	*s.*	*s.*	*s.*	*s.*		
July 11	7 20	80	488.43	1.36	487.07			
11	7 35	80	488.67	1.36	487.31	477.85		
11	5 05	76	488.63	1.09	487.54			
11	5 39	75	488.25	1.02	487.23			
					487.29	....	....	4.182

ALTOONA, PA.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
July 16	6 35	79	491.60	1.31	490.29			
16	8 20	74	492.91	0.96	491.95			
16	9 20	80	492.42	1.38	491.04	477.85		
16	5 35	75	491.72	1.03	490.69			
16	5 50	75	491.72	1.03	490.69			
					490.93	....	....	4.120

WILLIAMSPORT, PA.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
July 20	9 56	90.5	500.57	2.10	498.47			
20	10 50	94.5	500.97	2.38	498.59	477.85		
21	7 41	67.0	498.97	0.49	498.48			
21	8 09	73.0	497.67	0.91	496.76			
					498.08	....	....	4.003

BATH, N. Y.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
July 24	4 36	99.0	518.80	2.85	515.95			
24	5 22	95.5	519.32	2.64	516.68			
25	7 53	84.0	518.44	1.75	516.69	477.85		
25	8 09	85.0	518.02	1.82	516.20			
					516.38	....	....	3.724

ROCHESTER, N. Y.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
July 29	5 50	77.5	524.35	1.30	523.05			
29	6 38	74.5	523.51	1.06	522.45	477.85		
30	7 50	78.0	524.55	1.33	523.22			
					522.91	....	....	3.632

Observations for Intensity—Continued.

NIAGARA FALLS, N. Y.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
	h. m.	°	s.	s.	s.	s.		
July 31	5 50	77.5	523.23	1.28	521.95	477.85		
31	6 06	77	523.15	1.24	521.91			
Aug. 1	8 09	70	510.18	rejected				
1	8 29	68	509.82	rejected				
					521.93	....	....	3.646

MAYVILLE, N. Y.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
Aug. 4	9 25	75.5	517.15	1.13	516.02			
4	9 46	76.5	517.18	1.20	515.98			
4	10 13	77.0	516.98	1.22	515.76	477.85		
4	10 38	76.5	516.77	1.19	515.58			
4	5 51	76	516.77	1.15	515.62			
4	6 11	74.5	516.77	1.04	515.73			
					515.78	....	....	3.733

SHARPSVILLE, PA.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
Aug. 7	6 27	74	499.52	0.98	498.54			
7	6 41	74	497.27	0.98	496.29			
7	6 57	73	499.97	0.91	499.06	477.85		
7	8 27	70.5	498.96	0.73	498.23			
7	8 40	71.5	499.22	0.80	498.42			
					498.11	....	....	4.002

BEAVER, PA.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
Aug. 11	8 25	86	496.73	1.79	494.94			
11	8 38	88.5	496.78	1.93	494.85	477.85		
11	5 44	86	496.58	1.74	494.79			
11	5 57	87	496.53	1.86	494.67			
					494.81	....	....	4.056

GREENFIELD, PA.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
Aug. 13	5 57	83	489.02	1.56	487.46			
13	6 11	83	488.50	1.56	486.94			
14	8 56	82	488.42	1.49	486.93	477.85		
14	9 08	84	488.75	1.63	487.12			
					487.11	....	....	4.185

TUSCARAWAS, OHIO.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
Aug. 17	6 32	82.5	490.38	1.55	488.83			
17	6 44	81.0	490.07	1.45	488.62			
18	9 46	92.0	492.12	2.21	489.91	477.85		
18	9 19	90.5	491.86	2.10	489.76			
18	9 32	91.0	491.87	2.14	489.73			
					489.37	....	....	4.146

COLUMBUS, OHIO.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
Aug. 19	6 24	88	479.37	1.88	477.49	477.85		
19	6 38	85.5	478.77	1.71	477.06			
					477.27	....	....	4.359

Observations for Intensity—Continued.

FOREST, OHIO.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
	h. m.	°	s.	s.	s.			
Aug. 21	8 17	86	493.43	1.79	491.64	477.85		
21	8 30	88	493.58	1.93	491.65			
21	8 44	90	493.82	2.07	491.75			
21	4 54	93.5	494.02	2.31	491.71			
21	5 09	92	493.95	2.21	491.74			
21	5 36	90.5	493.52	2.10	491.42			
					491.65	....	....	4.108

FORT WAYNE, IND.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
Aug. 24	8 53	69	486.00	0.61	485.39	477.85		
24	9 07	70	486.07	0.68	485.49			
24	6 00	73	486.12	0.88	485.24			
24	6 14	73	485.62	0.88	484.74			
					485.21	....	....	4.218

REYNOLDS, IND.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
Aug. 27	9 05	78.5	487.32	1.26	486.06	477.85		
27	9 19	79	487.13	1.29	485.84			
26	6 01	72.5	486.05	0.85	485.20			
26	6 17	71.5	485.83	0.78	485.05			
					485.54	....	....	4.212

TERRE HAUTE, IND.

Date.	Time.	Temp.	Obs'd time of 120 vibrations.	Red'n to 60°.	T. Corrected.	T. Washington.	H. Relative.	H. Absolute.
Aug. 28	4 57	70	470.38	0.66	469.72	477.85		
28	5 09	70.5	470.52	0.69	469.83			
28	5 24	71	470.45	0.72	469.73			
29	9 06	72	469.63	0.79	468.84			
					469.53	....	....	4.505

1874.

GENERAL RESULTS.

STATIONS.

York, Pa.
Altoona, Pa.
Williamsport, Pa.
Bath, N. Y.
Rochester, N. Y.
Niagara Falls, N. Y.
Mayville, N. Y.
Sharpsville, Pa.
Beaver, Pa.
Greenfield, Pa.
Tuscarawas, Ohio.
Columbus, Ohio.
Forest, Ohio.
Fort Wayne, Ind.
Reynolds, Ind.
Terre Haute, Ind.

Chief of Party, F. E. HILGARD.

Observers, F. E. HILGARD, W. DIEHL.

GENERAL RESULTS.

MAGNETIC SURVEY, 1874.

YORK, PA.

Date.	Declination.	Dip.	Time of 120 vibrations. At——.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1874.	° ′	° ′	s.	s.	
July 11	3 56.3 W.	71 49.0	487.07		
	3 59.3 W.	71 57.3	487.31		
		71 52.7	487.54	477.85	
		71 53.5	487.23		
		71 55.8			
		71 53.7			
		71 55.3			
		71 59.0			
Means..	3 57.8 W.	71 54.5	487.29	....	4.182

ALTOONA, PA.

Date.	Declination.	Dip.	At——.	At Washington.	Horizontal intensity.
July 16	2 47.0 W.	72 21.4	490.29		
		72 21.1	491.95		
		72 20.0	491.04	477.85	
		72 24.2	490.69		
			490.69		
Means..	2 47.0 W.	72 21.7	490.93	....	4.120

WILLIAMSPORT, PA.

Date.	Declination.	Dip.	At——.	At Washington.	Horizontal intensity.
July 20	4 50.9 W.	72 50.6	498.47		
	4 52.9 W.	72 47.2	498.59		
	4 46.9 W.	72 49.3	498.48	477.85	
		72 42.9	496.76		
Means..	4 50.2 W.	72 47.5	498.08	....	4.003

BATH, N. Y.

Date.	Declination.	Dip.	At——.	At Washington.	Horizontal intensity.
July 24	5 32.2 W	74 19.3	515.95		
	5 36.7 W.	74 11.4	516.68		
		74 13.3	516.69	477.85	
		74 18.2	516.20		
Means..	5 34.4 W.	74 15.5	516.38	....	3.724

ROCHESTER, N. Y.

Date.	Declination.	Dip.	At——.	At Washington.	Horizontal intensity.
July 29	5 21.1 W.	74 46.7	523.05		
	5 14.6 W.	74 38.6	522.45		
		74 37.4	523.22	477.85	
		74 31.3			
Means..	5 17.8 W.	74 38.5	522.91	....	3.632

NIAGARA FALLS, N. Y.

Date.	Declination.	Dip.	At——.	At Washington.	Horizontal intensity.
July 31	3 32.9 W.	74 37.4	521.95		
	3 41.4 W.	74 39.4	521.91		
		74 35.8	....	477.85	
		74 38.2			
Means..	3 37.1 W.	74 37.7	521.93	....	3.646

General Results—Continued.

MAYVILLE, N. Y.

Date.	Declination.	Dip.	Time of 120 vibrations. At ——.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1874.	° ′	° ′	*s.*	*s.*	
Aug. 4	2 15.0 W.	74 05.2	516.02		
		74 05.2	515.98		
		74 01.5	515.76		
		74 08.0	515.58	477.85	
			515.62		
			515.73		
Means..	2 15.0 W.	74 05.0	515.78	....	3.733

SHARPSVILLE, PA.

Aug. 7	....	72 52.6	498.54		
First station.	1 00.0 W.	72 50.3	496.29		
		72 49.0	499.06	477.85	
Second station.	0 10.0 E.	72 51.0	498.23		
			498.42		
Means..	....	72 50.7	498.11	....	4.002

BEAVER, PA.

Aug. 11	1 08.2 W.	72 32.5	494.94		
		72 29.6	494.85		
		72 32.8	494.79	477.85	
		72 31.1	494.67		
Means..	1 08.2 W.	72 31.5	494.81	....	4.056

GREENFIELD, PA.

Aug. 13	2 06.5 W.	71 60.9	487.46		
	1 57.9 W.	71 56.7	486.94		
		71 58.8	486.93	477.85	
		71 59.4	487.12		
Means..	2 02.2 W.	71 58.9	487.11	....	4.185

TUSCARAWAS, OHIO.

Aug. 17	0 14.6 W.	72 09.0	488.83		
	0 24.8 W.	72 11.0	488.62		
		72 08.1	489.91	477.85	
		72 06.1	489.76		
			489.73		
Means..	0 19.7 W.	72 08.5	489.37	....	4.146

COLUMBUS, OHIO.

Aug. 19	1 12.1 E.	71 01.7	477.49		
		70 57.8	477.06	477.85	
Means..	1 12.1 E.	70 59.7	477.27	....	4.359

General Results—Continued.

FOREST, OHIO.

Date.	Declination.	Dip.	Time of 120 vibrations. At ——.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1874.	° ′	° ′	s.	s.	
Aug. 21	2 18.3 E.	72 18.6	491.64		
		72 21.0	491.65		
		72 22.1	491.75		
		72 21.0	491.71	477.85	
			491.74		
			491.42		
Means..	2 18.3 E.	72 20.7	491.65	....	4.108

FORT WAYNE, IND.

Aug. 24	2 33.9 E.	72 18.8	485.39		
	2 24.3 E.	72 20.5	485.49		
		72 18.0	485.24	477.85	
		72 18.6	484.74		
Means..	2 29.1 E.	72 19.0	485.21	....	4.218

REYNOLDS, IND.

Aug. 27	3 25.2 E.	72 00.4	486.06		
	3 35.4 E.	72 01.3	485.84		
		71 58.3	485.20	477.85	
		71 59.8	485.05		
Means..	3 30.3 E.	72 00.0	485.54	....	4.212

TERRE HAUTE, IND.

Aug. 29	4 29.1 E.	70 38.5	469.72		
	4 39.4 E.	70 38.0	469.83		
		70 28.8	469.73	477.85	
		70 33.6	468.84		
Means..	4 34.2 E.	70 34.7	469.53	....	4.505

1875.

DESCRIPTIONS OF STATIONS.

FERNANDINA, FLA.—The station is located near the spot on which the observations were made in 1857. It is 10 paces from the southwest extremity of the lot on which Mr. Rue's house stands. The mark taken is Amelia light-house.

LAKE CITY, FLA.—The station is on the eastern extremity of triangular lot of ground in front of Cathey House, about 12 paces from fence on north side of road. The mark is the eastern end of Mr. Pendleton's house (owned by Smithson).

TALLAHASSEE, FLA.—The station is in vacant lot on northeast corner of Adams and Pensacola streets. It is 46 paces from Pensacola street and 15 from Adams (from outer edge of sidewalk in both cases). The state-house bears northeast by east. The mark taken was the north end of the state-house.

SAINT MARK'S, FLA.—The station is in a lot in front of the United States signal station. The mark taken is the north edge of the signal station building. At the station the angle between mark and centre of door of signal station is 4° 00′, and between mark and northwest corner of railroad warehouse the angle is 78° 36′. From the mark both angles are in the direction of increasing azimuth.

EUFAULA, ALA.—The present station is on the first street west of the railroad (Forsyth street), and is nearly due west of the old magnetic station on Forsyth street. The latter was destroyed when the railroad was run along Forsyth street, and the stone which marked the spot is now used as a doorstep by Mrs. Stoveall, who lives directly opposite the place where it was dug up. The present station is marked by a stub driven 18 inches into the ground, in the middle of the street in front of a building occupied by a Mrs. Harden. The mark taken is the east wing of the Presbyterian church.

MONTGOMERY, ALA.—There is no description given.

EVERGREEN, ALA.—The station is on a hill on the east side of the railroad. It is on a lot next to Mr. Merten's house, and is distant 15 paces from the fence at the end of house near by. The mark taken is the western end of Mr. G. F. Merten's house. The angle between mark and the end of the hotel is 10° 42′.

MOBILE, ALA.—The station is near the city limits, in the part of the town known as Summerville, about two miles from the centre of the city. It is on the south side of the road, in an old fort nearly west of Saint Mary's church. To reach it from the city, take the Saint Francis street cars and get out at Saint Mary's church, and the station is on left side of road. The mark taken was the belfry of Saint Mary's church.

PASCAGOULA, MISS.—No description of station is given.

VICKSBURG, MISS.—The station is the same as that occupied by Dr. Hilgard in 1872. It is on Castle Hill, south end of bluff, opposite school-house, and is marked by a brick-stone and notch. References: Rev. C. K. Marshall; A. L. Peirce, city engineer; Mr. Max Kuner, watchmaker, and J. M. Searles, C. E., formerly of the Coast Survey. The mark is the southwest edge of masonry of upper tier of Cathedral steeple.

JACKSON, MISS.—The station is on a bald spot in rear of the free school, northeast of the state-house. The mark is a cross on a church southwest. The same point was occupied by Dr. Hilgard in 1872.

WEST POINT, MISS.—The station is in the centre of a large vacant lot back of the Jackson House and south of the court-house.

MERIDIAN, MISS.—The station is in a lot on Main street, west of the Chattanooga railroad shops. It is located by the following angles:

	°	′
Northeast corner Peck and Kunbrough's	0	00
Northeast corner Kenzee store	93	12
South end Meyer's livery stable	208	47
Chattanooga railroad shops	322	27

TUSCALOOSA, ALA.—The station is located in the grounds of the University of Alabama, and is in the meridian and 20 yards south of the transit in the university observatory. For references apply to Prof. E. A. Smith, State geologist, or to Professor Whitfield. The mark is the chimney on north end of the president's house.

BIRMINGHAM, ALA.—The station is in a lot northeast of the new court-house, in a northeast and southwest line from the cupola of the court-house to ridge of a house belonging to G. M. Cooper. The mark is the court-house cupola. The angle between it and the spire of the Catholic church is 86° 06′, the latter being southeast from the station.

SELMA, ALA.—The station is in a lot known as the "old arsenal lot," on the west side of the river, east of Alabama street and south of Union street, and 10 paces from the edge of the bluff. The mark taken was the spire of the Methodist steeple on Church street.

OPELIKA, ALA.—The station is on Tallapoosa street, on a lot part of which is occupied by the Presbyterian church. The station is 30 paces from the church, on a line with the front, parallel to the street. The mark is a belfry in rear of the church.

MACON, GA.—The station is 12 paces west of a former Coast Survey station, marked by a stone post, with the letters U. S. C. S.

MILLEDGEVILLE, GA.—The station is situated on the old capitol grounds, upon a raised terrace of earth upon which during the war a gun was planted. It is south of the southwest tower on the capitol. The station is in the centre of the mound. The mark is the spire of the southwest tower, which has the lightning rod on it.

LUMBER CITY, GA.—The station is in a lot belonging to Colonel Boyd, and is about a quarter of a mile north of the railroad. To find it, take the road leading to old Lumber City. On crossing the first ditch there is a pine tree at edge of road. The station is about 50 yards due east of this tree. The mark is the west end of Station No. 9.

MILLEN, GA.—The station is in an open lot 35 paces southwest of corner of building used as a Masonic lodge. The mark is the west end of wood mill belonging to the Georgia Central Railroad.

COLUMBIA, S. C.—The station is situated in southwest corner of Capitol Square, as near the location of the old station as could be determined. It is about 20 paces from the fence. The mark taken is the flagstaff on the capitol.

FLORENCE, S. C.—The station is on Coit street, about 600 yards from the railroad, and is 25 paces southeast of the old African church, and on a line with the sidewalk of the street. The mark taken is the steeple of the Colored Methodist church.

GOLDSBOROUGH, N. C.—The station is situated on a lot on the southeast corner of John and Spruce streets. It is 30 paces from the sidewalk on Spruce street and 30 paces from John street. The mark taken is the Methodist church steeple.

WELDON, N. C.—The station is west of the Methodist church, on a lot bounded by Mrs. Allen's, Mrs. Brown's, and Mr. Smalley's. It is 15 paces northwest of Mrs. Allen's fence. The mark taken is the Baptist church dome.

WILMINGTON, DEL.—The station is at the northwest corner of Fourth and Brown streets, at the corner stone of the streets. The mark taken is Grace church steeple, to the northeast.

1875.

OBSERVATIONS FOR DECLINATION.*

STATIONS.

Fernandina, Fla.	Mobile, Ala.	Birmingham, Ala.	Millen, Ga.
Lake City, Fla.	Pascagoula, Miss.	Selma, Ala.	Columbia, S. C.
Tallahassee, Fla.	Vicksburg, Miss.	Opelika, Ala.	Florence, S. C.
Saint Mark's, Fla.	Jackson, Miss.	Macon, Ga.	Goldsborough, N. C.
Eufaula, Ala.	West Point, Miss.	Milledgeville, Ga.	Weldon, N. C.
Montgomery, Ala.	Meridian, Miss.	Lumber City, Ga.	Wilmington, Del.
Evergreen, Ala.	Tuscaloosa, Ala.		

Observer, J. M. POOLE.

*No observations for dip or intensity.

EXPLANATION OF TABLE.

1. The first column gives the date of the observations for azimuth and declination.
2. The second column gives the observed zenith distance of the sun's limb corrected for semi-diameter, parallax, and refraction.
3. The third column gives the azimuth of ⊙, corresponding to the zenith distance in the second column.
4. The fourth column gives the reading of ⊙ on the horizontal circle.
5. The difference (or sum*) of the quantities in the third and fourth columns gives those in the fifth column.
6. The sixth column gives the reading of the magnetic meridian† corresponding to the reading of ⊙ given in column 4.
7. The seventh column gives the resulting declination.

OBSERVATIONS FOR DECLINATION.

MAGNETIC SURVEY, 1875

FERNANDINA, FLA. $\phi=30° 40'.6$.

Date.	Corrected Z. D. ⊙	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
1875.	° ′	° ′	° ′	° ′	° ′	° ′	
May 14, a. m.	67 38.0	80 58.3	158 54.2	77 55.9	80 50.0	2 54.1	E.
14, a. m.	65 15.2	82 14.7	160 07.2	77 52.5	80 49.0	2 56.5	E.
						2 55.3	E.

LAKE CITY, FLA. $\phi=30° 11'$.

Date.	Corrected Z. D. ⊙	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
May 15, p. m.	77 54.1	74 57.3	275 43.4	350 40.6	354 01.0	3 20.4	E.

TALLAHASSEE, FLA. $\phi=30° 25'.5$.

Date.	Corrected Z. D. ⊙	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
May 18, a. m.	72 17.4	77 19.6	280 48.5	203 28.9	207 10.8	3 41.9	E.
18, a. m.	69 56.8	78 34.0	282 03.5	203 29.5	207 11.0	3 41.5	E.
						3 41.7	E.

SAINT MARK'S, FLA. $\phi=30° 08'.1$.

Date.	Corrected Z. D. ⊙	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
May 18, p. m	65 08.2	80 50.8	212 19.0	293 09.8	297 40.4	4 30.6	E.
18. p. m.	67 35.7	79 35.0	213 35.5	293 10.5	297 40.4	4 29.9	E.
						4 30.3	E.

EUFAULA, ALA. $\phi=31° 53'.7$.

Date.	Corrected Z. D. ⊙	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
May 22, p. m.	57 49.7	84 34.0	3 14.9	87 48.9	92 20.8	4 31.9	E.
22, p. m.	61 10.4	82 41.6	5 07.8	87 49.4	92 23.6	4 34.2	E.
						4 33.0	E.

MONTGOMERY, ALA. $\phi=32° 22'.7$.

Date.	Corrected Z. D. ⊙	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
May 24, p. m.	55 34.0	85 39.0	240 51.2	326 33.2	331 12.0	4 38.8	E.
24, p. m.	61 00.1	82 32.0	244 02.0	326 34.0	331 12.8	4 38.8	E.
						4 38.8	E.

*The "Azimuth of ⊙" is taken to mean the smaller of the angles formed by the plane of the north meridian and the vertical plane through the ⊙. For p. m. observations it is therefore counted from north to west, and is additive to the reading of ⊙ to get reading of true north.

†In all observations in 1875 the reading on the magnetic meridian was taken at the same time as the reading on the mark and the observations for azimuth. The reading of mark does not, therefore, necessarily enter into the computation.

Observations for Declination—Continued.

EVERGREEN, ALA. $\phi=31° 26'.0$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
1875.	° ′	° ′	° ′	° ′	° ′	° ′	
May 25, p. m.	57 16.5	83 52.0	219 05.7	302 57.7	308 32.4	5 34.7	E.
25, p. m.	64 13.7	80 06.8	222 50.1	302 56.9	308 26.0	5 29.1	E.
						5 31.9	E.

MOBILE, ALA. $\phi=30° 41'.4$.

May 27, h. m.	56 06.0	83 36.4	285 57.6	9 34.0	15 41.0	6 07.0	E.

PASCAGOULA, MISS. $\phi=30° 21'$.

May 28, a. m.	60 37.3	80 59.4	93 00.7	12 01.3	18 25.0	6 23.7	E.
28, p. m.	78 47.9	71 30.0	120 33.4	192 03.4	198 18.7	6 15.3	E.
						6 19.5	E.

VICKSBURG, MISS. $\phi=32° 17'.3$.

June 3, p. m.	61 35.6	80 12.7	266 55.6	347 08.3	354 27.0	7 18.7	E.
3, p. m.	63 50.5	78 58.8	268 09.0	347 07.8	174 27.0	7 19.2	E.
3, p. m.	66 19.9	77 36.6	269 31.2	347 07.8	174 27.0	7 19.2	E.
						7 19.0	E.

JACKSON, MISS. $\phi=32° 17'.0$.

June 4, p. m.	76 18.3	71 50.2	344 47.5	56 47.7	64 25.4	7 47.7	E.
4, p. m.	78 28.7	70 33.2	346 05.0	56 38.2	64 25.2	7 47.0	E.
5, a. m.	72 42.4	73 50.8	130 27.2	56 36.4	64 23.2	7 46.8	E.
						7 47.2	E.

WEST POINT, MISS. $\phi=33° 33'.2$.

June 7, p. m.	57 45.9	82 28.0	289 29.4	11 57.4	18 25.0	6 27.6	E.
7, p. m.	62 56.6	79 26.1	292 30.2	11 56.3	18 19.7	6 23.4	E.
						6 25.5	E.

MERIDIAN, MISS. $\phi=32° 20'$.

June 8, a. m.	74 09.2	72 40.0	252 49.0	180 09.0	186 36.0	6 27.0	E.
8, a. m.	72 12.2	73 46.0	253 57.1	180 11.1	186 36.0	6 24.9	E.
						6 26.0	E.

TUSCALOOSA, ALA. $\phi=33° 12'.1$.

June 8, p. m.	71 28.0	74 17.4	31 44.3	106 01.7	112 07.0	6 05.3	E.
9, a. m.	61 15.2	80 05.0	139 11.3	59 06.3	65 10.4	6 04.1	E.
						6 04.7	E.

BIRMINGHAM, ALA. $\phi=33° 32'.0$.

June 10, p. m.	59 01.7	81 22.0	224 33.3	305 55.3	310 20.6	4 25.3	E.
10, p. m.	62 20.2	79 27.3	226 29.1	305 56.4	310 23.4	4 27.0	E.
						4 26.1	E.

Observations for Declination—Continued.

SELMA, ALA. $\phi=32° 24'.6$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Decli-nation.	E. or W. of north.
1875.	° ′	° ′	° ′	° ′	° ′	° ′	
June 11, p. m.	60 33.0	79 53.0	267 44.2	347 37.2	352 09.2	4 32.0	E.
11, p. m.	64 26.6	77 45.6	269 50.5	347 36.1	352 08.6	4 32.5	E.
						4 32.2	E.

OPELIKA, ALA. $\phi=32° 39'.5$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Decli-nation.	E. or W. of north.
June 12, p. m.	62 09.0	79 02.0	355 02.0	74 04.0	78 38.4	4 34.4	E.
12, p. m.	66 17.5	76 44.7	357 25.1	74 09.8	78 39.0	4 29.2	E.
						4 31.8	E.

MACON, GA. $\phi=32° 50'.4$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Decli-nation.	E. or W. of north.
June 14, p. m.	64 20.6	77 45.1	235 54.6	313 39.7	137 09.4	3 29.7	E.
14, p. m.	66 31.0	76 32.3	237 08.4	313 40.7	137 09.0	3 28.3	E.
						3 29.0	E.

MILLEDGEVILLE, GA. $\phi=33° 04'.2$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Decli-nation.	E. or W. of north.
June 15, p. m.	64 41.0	77 35.3	278 37.7	356 13.0	360 28.4	4 15.4	E.
15, p. m.	66 53.8	76 20.4	279 58.6	356 19.0	360 31.8	4 12.8	E.
						4 14.1	E.

LUMBER CITY, GA. $\phi=31° 57'.2$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Decli-nation.	E. or W. of north.
June 17, p. m.	63 26.7	77 46.7	238 22.2	316 08.9	319 19.8	3 10.9	E.
17, p. m.	68 33.1	75 03.0	241 05.7	316 08.7	319 19.4	3 10.7	E.
						3 10.8	E.

MILLEN, GA. $\phi=32° 50'.5$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Decli-nation.	E. or W. of north.
June 22, a. m.	63 41.5	77 54.7	135 19.2	57 24.5	60 02.4	2 37.9	E.
22, a. m.	61 49.6	78 57.0	136 22.0	57 25.0	60 01.8	2 36.8	E.
						2 37.3	E.

COLUMBIA, S. C. $\phi=34° 00'.0$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Decli-nation.	E. or W. of north.
June 23, p. m.	62 09.0	79 15.7	215 21.5	294 37.2	296 26.0	1 48.8	W.
23, p. m.	65 33.8	77 15.2	217 22.0	294 37.2	296 27.0	1 49.8	W.
						1 49.3	W.

FLORENCE, S. C. $\phi=34° 11'.9$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Decli-nation.	E. or W. of north.
June 25, a. m.	67 52.0	75 59.0	83 00.7	7 01.7	8 14.8	1 31.1	E.
25, a. m.	65 27.8	77 24.9	84 26.5	7 01.6	8 13.0	1 11.4	E.
						1 12.2	E.

GOLDSBOROUGH, N. C. $\phi=35° 25'.1$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Decli-nation.	E. or W. of north.
June 28, p. m.	62 42.8	79 41.2	336 47.6	46 28.8	46 13.0	0 15.8	W.
28, p. m.	64 41.1	78 26.8	328 01.6	46 28.4	46 14.0	0 14.4	W.
						0 15.1	W.

Observations for Declination—Continued.

WELDON, N. C. $\phi=36° 27'.2$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
1875.	° ′	° ′	° ′	° ′	° ′	° ′	
June 29, a. m.	71 15.5	74 28.3	123 02.6	48 34.3	46 53.0	1 41.3	W.
29, a. m.	67 40.1	76 51.6	125 24.9	48 33.3	46 53.2	1 40.1	W.
						1 40.7	W.

WILMINGTON, DEL. $\phi=39° 46'.6$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
July 1, a. m.	68 17.5	77 21.1	166 00.7	88 39.6	84 32.2	4 07.4	W.
1, a. m.	65 12.4	79 42.0	168 20.5	88 38.5	84 31.4	4 07.1	W.
						4 07.3	W.

1875.

OBSERVATIONS FOR LOCAL TIME.

STATIONS.

Fernandina, Fla.
Lake City, Fla.
Tallahassee, Fla.
Saint Mark's, Fla.
Eufaula, Ala.
Montgomery, Ala.
Evergreen, Ala.
Mobile, Ala.
Pascagoula, Miss.
Vicksburg, Miss.
Jackson, Miss.
West Point, Miss.
Meridian, Miss.
Tuscaloosa, Ala.
Birmingham, Ala.
Selma, Ala.
Opelika, Ala.
Macon, Ga.
Milledgeville, Ga.
Lumber City, Ga.
Millen, Ga.
Columbia, S. C.
Florence, S. C.
Goldsborough, N. C.
Weldon, N. C.
Wilmington, Del.

Observer, J. M. POOLE.

MAGNETIC SURVEY, 1875.

FERNANDINA, FLA. $\phi=30° 40'.6$.

Date.	Corrected Z. D. ⊙	Mean time of observation.	Time by chronometer.	Chronometer fast.
1875.	° ′	h. m. s.	h. m. s.	m. s.
May 14, a. m.	67 38.0	6 58 09	7 20 14	22 05
14, a. m.	65 15.2	7 09 19	7 31 31	22 12

LAKE CITY, FLA. $\phi=30° 11'.0$.

Date.	Corrected Z. D. ⊙	Mean time of observation.	Time by chronometer.	Chronometer fast.
May 15, p. m.	77 54.1	5 43 10	6 08 43	25 33

TALLAHASSEE, FLA. $\phi=30° 25'.4$.

Date.	Corrected Z. D. ⊙	Mean time of observation.	Time by chronometer.	Chronometer fast.
May 18, a. m.	72 17.4	6 34 26	7 07 22	32 56
18, a. m.	69 56.8	6 45 33	7 18 28	32 55

SAINT MARK'S, FLA. $\phi=30° 08'.1$.

Date.	Corrected Z. D. ⊙	Mean time of observation.	Time by chronometer.	Chronometer fast.
May 18, p. m.	65 08.2	4 44 10	5 16 52	32 42
18, p. m.	67 35.7	4 55 42	5 28 10	32 28

Observations for Local Time—Continued.

EUFAULA, ALA. $\phi = 31° 53'.7$.

Date.	Corrected Z. D. ⊙	Mean time of observation.	Time by chronometer.	Chronometer fast.
1875.	° ′	*h. m. s.*	*h. m. s.*	*m. s.*
May 22, p. m.	57 49.7	4 12 40	4 49 15	36 35
22, p. m.	61 10.4	4 28 32	5 05 02	36 30

MONTGOMERY, ALA. $\phi = 32° 22'.7$.

May 24, p. m.	55 34.0	4 03 05	4 44 19	41 14
24, p. m.	61 00.1	4 28 58	5 10 07	41 09

EVERGREEN, ALA. $\phi = 31° 26'.0$.

May 25, p. m.	57 16.5	4 11 14	4 54 56	43 42
25, p. m.	64 13.7	4 44 10	5 27 54	43 44

MOBILE, ALA. $\phi = 30° 41'.4$.

May 27, p. m.	56 06.0	4 06 11	4 54 38	48 27

PASCAGOULA, MISS. $\phi = 30° 21'$.

May 28, a. m.	60 37.3	7 26 31	8 16 37	50 06
28, p. m.	78 47.9	5 54 27	6 44 37	50 10

VICKSBURG, MISS. $\phi = 32° 17'.3$.

June 3, p. m.	61 35.6	4 36 14	5 35 52	59 38
3, p. m.	63 50.4	4 47 03	5 46 46	59 43
3, p. m.	66 19.9	4 59 05	5 58 50	59 45

JACKSON, MISS. $\phi = 32° 17'.0$.

June 4, p. m.	76 18.3	5 48 26	6 45 10	56 44
4, p. m.	78 28.7	5 59 19	6 56 03	56 44
5, a. m.	72 42.4	6 25 22	7 22 09	56 47

WEST POINT, MISS. $\phi = 33° 33'.2$.

June 7, p. m.	57 45.9	4 20 18	5 10 59	50 41
7, p. m.	62 56.6	4 45 29	5 36 07	50 38

MERIDIAN, MISS. $\phi = 32° 20'$.

June 8, a. m.	74 09.2	6 17 58	7 08 39	50 41
8, a. m.	72 12.2	6 27 38	7 18 18	50 40

TUSCALOOSA, ALA. $\phi = 33° 12'.1$.

June 8, p. m.	71 28.0	5 27 28	6 13 20	45 52
9, a. m.	61 15.2	7 20 16	8 06 10	45 54

BIRMINGHAM, ALA. $\phi = 33° 32'$.

June 10, p. m.	59 01.7	4 27 37	5 10 46	43 09
10, p. m.	62 20.2	4 43 42	5 26 59	43 17

SELMA, ALA. $\phi = 32° 24'.6$.

June 11, p. m.	60 32.9	4 34 10	5 18 18	44 08
11, p. m.	64 26.6	4 53 14	5 37 15	44 01

Observations for Local Time—Continued.

OPELIKA, ALA. $\phi = 32° 39'.5$.

Date.	Corrected Z. D. ☉	Mean time of observation.	Time by chronometer.	Chronometer fast.
1875.	° ′	h. m. s.	h. m. s.	m. s.
June 12, p. m.	62 08.9	4 42 42	5 20 00	37 18
12, p. m.	66 17.5	5 02 51	5 40 13	37 22

MACON, GA. $\phi = 32° 50'.4$.

June 14, p. m.	64 20.6	4 54 11	5 24 18	30 07
14, p. m.	66 31.0	5 04 48	5 34 56	30 08

MILLEDGEVILLE, GA. $\phi = 33° 04'.2$.

June 15, p. m.	64 41.0	4 56 23	5 25 08	28 45
15, p. m.	66 53.8	5 07 14	5 35 55	28 41

LUMBER CITY, GA. $\phi = 31° 57'.2$.

June 17, p. m.	63 26.7	4 49 46	5 16 14	26 28
17, p. m.	68 33.1	5 14 33	5 41 01	26 28

MILLEN, GA. $\phi = 32° 50'.5$.

June 22, a. m.	63 41.5	7 10 00	7 34 00	24 00
22, a. m.	61 49.6	7 19 02	7 43 05	24 03

COLUMBIA, S. C. $\phi = 34° 00'.0$.

June 23, p. m.	62 09.0	4 46 49	5 07 04	20 15
23, p. m.	65 33.8	5 03 38	5 23 53	20 15

FLORENCE, S. C. $\phi = 34° 11'.9$.

June 25, a. m.	67 51.9	6 48 53	7 03 50	14 57
25, a. m.	65 27.8	7 00 50	7 15 47	14 57

GOLDSBOROUGH, N. C. $\phi = 35° 25'.1$.

June 28, p. m.	62 42.8	4 51 34	4 59 24	7 50
28, p. m.	64 41.1	5 01 26	5 09 17	7 51

WELDON, N. C. $\phi = 36° 27'.2$.

June 29, a. m.	71 15.4	6 30 07	6 36 22	6 15
29, a. m.	67 40.1	6 48 25	6 54 43	6 18

WILMINGTON, DEL. $\phi = 30° 46'.6$.

July 1, a. m.	68 17.5	6 42 04	6 40 26	— 1 38
1, a. m.	65 12.4	6 58 26	6 56 51	— 1 35

1875.

OBSERVATIONS FOR DECLINATION.*

STATIONS.

Lebanon, Mo.
Poplar Bluff, Mo.
Little Rock, Ark.
Memphis, Tenn.
Corinth, Miss.
Florence, Ala.
Madison, Ala.
Cleveland, Tenn.
Knoxville, Tenn.
Guthrie, Ky.
Crofton, Ky.
Evansville, Ind.
Portland, Ky.
Cave City, Ky.
Nicholasville, Ky.
Maysville, Ky.
Huntingdon, W. Va.

Observer, F. E. HILGARD.

MAGNETIC SURVEY, 1875.

LEBANON, MO. $\phi = 37° 38'.0$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
1875.	° ′	° ′	° ′	° ′	° ′	° ′	
May 12, a. m.	73 10.7	79 49.3	237 01.5	157 12.2	165 33.0	8 20.8	E.
12, a. m.	61 32.0	88 23.3	245 35.8	157 12.5	165 32.0	8 19.5	E.
12, p. m.	68 45.7	82 52.0	74 21.0	157 13.0	165 26.0	8 13.0	E.
12, p. m.	74 23.1	78 46.0	78 26.0	157 12.0	165 23.0	8 11.0	E.
						8 16.1	E.

POPLAR BLUFF, MO. $\phi = 36° 45'$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
May 17, a. m.	80 38.7	72 50.0	107 18.0	34 28.0	41 47.4	7 19.4	E.
17, a. m.	74 50.7	77 00.0	111 26.0	34 26.0	41 41.0	7 15.0	E.
17, a. m.	68 22.4	81 30.0	115 57.0	34 27.0	41 44.0	7 17.0	E.
17, a. m.	62 52.3	85 20.4	119 49.1	34 28.7	41 45.4	7 16.7	E.
						7 17.0	E.
17, p. m.	50 45.2	94 18.0	300 08.0	34 26.0	41 32.0	7 06.0	E.
17, p. m.	54 57.0	91 00.0	303 27.0	34 27.0	41 37.0	7 10.0	E.
						7 08.0	E.
						7 12.5	E.

LITTLE ROCK, ARK. $\phi = 34° 46'$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
May 18, p. m.	60 22.5	85 40.0	248 33.6	334 13.6	342 26.0	8 12.4	E.
18, p. m.	72 33.2	77 50.0	256 21.7	334 11.7	342 25.0	8 13.3	E.
18, p. m.	76 09.2	75 30.0	258 43.0	334 13.0	342 25.0	8 12.0	E.
						8 12.6	
20, a. m.	58 48.8	86 14.7	60 28.0	334 13.3	342 22.0	8 08.7	
						8 10.6	

MEMPHIS, TENN. $\phi = 35° 13'$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
May 24, p. m.	61 06.8	83 48.5	337 08.0	60 56.5	67 53.0	6 56.5	E.
24, p. m.	67 40.3	79 35.2	341 20.7	60 55.9	67 54.0	6 58.1	E.
24, p. m.	72 23.6	76 32.5	344 22.5	60 55.0	67 52.3	6 57.3	E.
						6 57.3	E.
25, a. m.	62 08.0	83 01.7	143 49.9	60 48.2	67 54.0	7 05.8	E.
25, a. m.	56 16.1	86 52.6	147 39.2	60 46.6	67 54.0	7 07.4	E.
						7 06.6	E.
						7 01.9	E.

* No observations for dip or intensity.

Observations for Declination—Continued.

CORINTH, MISS. $\phi = 34^\circ\ 57'$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
1875.	° ′	° ′	° ′	° ′	° ′	° ′	
May 27, a. m.	70 50.9	76 56.0	320 14.7	243 18.7	249 44.0	6 25.3	E.
27, a. m.	65 57.5	79 56.2	323 18.5	243 22.3	249 45.6	6 23.3	E.
27, a. m.	60 12.6	83 40.2	326 59.7	243 19.5	249 45.4	6 25.9	E.
						6 24.8	E.
27, p. m.	60 25.8	83 26.7	159 51.6	243 18.3	249 38.0	6 19.7	E.
27, p. m.	64 06.7	81 06.5	162 14.4	243 20.9	249 38.0	6 17.1	E.
						6 18.4	E.
						6 21.6	E.

FLORENCE, ALA. $\phi = 34^\circ\ 47'.2$.

May 29, p. m.	49 09.0	90 22.0	181 15.0	271 37.0	276 52.5	5 15.5	E.
29, p. m.	58 20.6	84 16.0	187 19.7	271 35.7	276 49.0	5 13.3	E.
29, p. m.	62 35.8	81 34.8	190 01.4	276 36.2	276 50.0	5 13.8	E.
29, p. m.	67 03.8	78 47.5	192 51.0	271 38.5	276 53.0	5 14.5	E.
29, p. m.	71 41.0	75 53.4	195 45.6	271 39.0	276 54.0	5 15.0	E.
						5 14.4	

MADISON, ALA. $\phi = 34^\circ\ 40'.6$.

May 31, a. m.	78 47.0	71 01.1	319 52.2	248 51.1	254 06.0	5 14.9	E.
31, a. m.	66 31.1	78 48.7	327 40.5	248 51.8	254 08.0	5 16.2	E.
						5 15.5	E.
31, p. m.	64 29.2	79 59.2	168 52.5	248 51.7	253 56.0	5 04.3	E.
31, p. m.	69 54.2	76 37.6	172 15.4	248 53.0	254 02.0	5 09.0	E.
31, p. m.	75 03.7	73 21.7	175 32.6	248 54.3	254 04.0	5 09.7	E.
						5 07.7	E.
						5 11.6	E.

CLEVELAND, TENN. $\phi = 35^\circ\ 09'.9$.

June [illegible], p. m.	59 19.1	83 06.0	73 30.4	156 36.4	159 34.5	2 58.1	E.
2, p. m.	64 03.7	80 05.6	76 33.2	156 38.8	159 35.0	2 56.2	E.
2, p. m.	70 11.1	76 13.1	80 26.2	156 39.3	159 35.0	2 55.7	E.
2, p. m.	75 49.4	72 34.0	84 03.6	156 37.6	159 34.6	2 57.0	E.
						2 56.7	E.
3, a. m.	Not obse	rved	....	156 38.0	159 41.4	3 03.4	E.
						3 00.0	E.
June 17, p. m.	48 18.2	88 40.6	51 02.0	139 42.6	143 13.4	3 30.8	E.
17, p. m.	62 31.3	79 33.3	60 09.5	139 42.8	143 10.4	3 27.6	E.
18, a. m.	61 08.2	80 23.7	220 08.0	139 44.3	143 16.0	3 31.7	E.
18, a. m.	56 06.7	83 32.4	223 16.1	139 43.7	143 16.0	3 32.3	E.
						3 30.6	E.

KNOXVILLE, TENN. $\phi = 35^\circ\ 56'.0$.

June 7, p. m.	54 20.9	86 03.2	62 12.1	148 15.3	149 57.0	1 41.7	E.
7, p. m.	60 28.4	81 59.3	66 18.3	148 17.6	149 58.0	1 40.4	E.
7, p. m.	64 10.1	79 35.5	68 43.4	148 18.9	149 57.0	1 38.1	E.
7, p. m.	68 57.8	76 28.4	71 49.5	148 17.9	149 56.0	1 38.1	E.
7, p. m.	73 45.6	73 18.5	75 00.0	148 18.5	149 58.0	1 39.5	E.
						1 39.6	E.

Observations for Declination—Continued.

KNOXVILLE, TENN.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
1875.	° ′	° ′	° ′	° ′	° ′	° ′	
June 14, p.m.	58 34.4	82 34.0	67 43.0	150 17.0	152 31.0	2 14.0	E.
14, p.m.	63 48.1	79 10.9	71 04.0	150 14.9	152 31.0	2 16.1	E.
						2 15.0	E.
16, a.m.	78 48.5	69 09.6	219 26.0	150 16.4	152 30.6	2 14.2	E.
16, a.m.	72 05.4	73 42.9	224 00.5	150 17.6	152 32.5	2 14.9	E.
16, a.m.	67 38.3	76 37.6	226 54.9	150 17.3	152 34.0	2 16.7	E.
						2 15.3	E.
						2 15.2	E.

GUTHRIE, KY. $\phi = 36° 36'.0$.

June 21, p.m.	47 47.2	90 14.0	54 51.6	145 05.6	151 45.5	6 39.9	E.
21, p.m.	54 16.1	85 36.4	59 30.8	145 07.2	151 45.6	6 38.4	E.
21, p.m.	58 54.6	82 27.7	62 36.0	145 03.7	151 49.0	6 45.3	E.
23, a.m.	78 48.8	69 00.0	164 53.6	95 53.6	102 41.0	6 47.4	E.
23, a.m.	73 19.7	72 50.6	168 43.9	95 53.3	102 39.6	6 46.3	E.
23, a.m.	68 19.1	76 13.4	172 08.0	95 54.6	102 40.0	6 45.4	E.
						6 43.8	

CROFTON, KY. $\phi = 37° 02'.2$.

June 24, a.m.	78 18.1	69 21.7	162 33.1	93 11.4	99 26.0	6 14.6	E.
24, a.m.	72 32.8	73 26.4	166 37.7	93 11.3	99 26.0	6 14.7	E.
24, a.m.	67 23.9	76 58.0	170 09.1	93 11.1	99 26.0	6 14.9	E.
24, p.m.	55 17.8	85 13.3	8 13.1	93 26.4	99 42.4	6 16.0	E.
24, p.m.	61 00.7	81 17.7	12 09.2	93 26.9	99 45.1	6 18.2	E.
24, p.m.	69 15.5	75 42.7	17 44.0	93 26.7	99 42.6	6 15.9	E.
						6 15.7	E.

EVANSVILLE, IND. $\phi = 38° 00'.0$.

June 25, p.m.	54 17.5	86 36.5	337 34.8	64 11.3	70 19.0	6 07.7	E.
25, p.m.	58 27.2	83 34.7	340 36.6	64 11.3	70 19.6	6 08.3	E.
						6 08.0	E.
26, a.m.	76 11.1	70 56.5	135 07.2	64 10.7	70 20.0	6 09.3	E.
26, a.m.	70 17.7	75 12.9	139 22.5	64 09.6	70 20.0	6 10.4	E.
26, a.m.	64 34.0	79 16.0	143 25.5	64 09.5	70 22.0	6 12.5	E.
						6 10.7	E.
						6 09.4	E.

PORTLAND, KY. $\phi = 38° 16'.3$.

June 30, p.m.	54 26.8	87 00.0	141 03.6	228 03.6	231 42.0	3 38.4	E.
30, p.m.	60 16.1	82 43.1	145 20.2	228 03.3	231 42.0	3 38.7	E.
30, p.m.	66 38.9	78 08.6	149 57.0	228 05.6	231 41.0	3 35.4	E.
						3 37.5	E.
July 1, a.m.	72 32.6	73 56.5	301 59.0	228 02.5	231 41.5	3 39.0	E.
1, a.m.	68 03.6	77 11.0	305 13.4	228 02.4	231 40.0	3 37.6	E.
						3 38.3	E.
						3 37.9	E.

Observations for Declination—Continued.

CAVE CITY, KY. $\phi = 37°\ 10'.0$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
1875.	° ′	° ′	° ′	° ′	° ′	° ′	
July 1, p.m.	62 20.7	80 51.7	302 10.8	23 02.5	29 01.0	5 58.5	E.
1, p.m.	67 49.8	77 07.0	305 56.4	23 03.4	28 53.0	5 49.6	E.
						5 54.1	E.
2, a.m.	Not observed			23 01.1	28 56.0	5 54.9	E.
2, a.m.	67 29.9	77 24.0	100 25.4	23 01.4	29 00.0	5 58.6	E.
2, a.m.	60 43.4	82 01.7	105 02.4	23 00.7	28 52.0	5 51.3	E.
						5 54.9	E.
						5 54.5	E.

NICHOLASVILLE, KY. $\phi = 37°\ 55'.6$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
July 7, a.m.	77 51.4	70 39.7	237 15.2	166 35.5	169 24.5	2 49.0	E.
7, a.m.	71 13.0	75 31.0	242 05.4	166 34.4	169 21.6	2 47.2	E.
7, a.m.	Not observed			166 35.0	169 28.5	2 53.5	E.
7, p.m.	61 37.9	82 23.7	84 13.3	166 37.0	169 19.4	2 42.4	E.
7, p.m.	69 30.0	76 48.5	89 47.7	166 36.2	169 25.0	2 48.8	E.
7, p.m.	75 30.8	72 28.0	94 06.5	166 34.5	169 23.4	2 48.9	E.
						2 48.3	E.

MAYSVILLE, KY. $\phi = 38°\ 41'.0$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
July 9, p.m.	52 42.8	89 51.0	39 49.6	129 40.6	129 37.6	0 03.0	W.
9, p.m.	56 43.1	86 43.6	42 58.5	129 42.1	129 39.4	0 02.7	W.
						0 02.9	W.
10, a.m.	Not observed			129 41.3	129 45.0	0 03.7	E.
						0 00.4	E.

HUNTINGTON, W. VA. $\phi = 38°\ 27'.0$.

Date.	Corrected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mag. meridian reads.	Declination.	E. or W. of north.
July 13, a.m.	78 52.0	70 48.9	166 22.9	95 34.0	96 24.0	0 50.0	E.
13, a.m.	72 29.2	75 37.4	171 09.4	95 32.0	96 26.6	0 54.4	E.
13, a.m.	68 31.2	78 32.0	174 03.5	95 31.5	96 26.0	0 54.5	E.
						0 53.0	E.
13, p.m.	47 59.4	94 24.0	1 10.9	95 34.9	96 16.0	0 41.1	E.
						0 47.0	E.

1875.

OBSERVATIONS FOR LOCAL TIME.

STATIONS.

Lebanon, Mo.
Poplar Bluff, Mo.
Little Rock, Ark.
Memphis, Tenn.
Corinth, Miss.

Florence, Ala.
Madison, Ala.
Cleveland, Tenn.
Knoxville, Tenn.

Guthrie, Ky.
Crofton, Ky.
Evansville, Ind.
Portland, Ky.

Cave City, Ky.
Nicholasville, Ky.
Maysville, Ky.
Huntington, W. Va.

Observer, F. E. HILGARD.

OBSERVATIONS FOR LOCAL TIME.

MAGNETIC SURVEY, 1875.

LEBANON, MO. $\phi = 37° 38'.0$.

Date.	Corrected Z. D. ☉.	Mean time of obs'n.	Time by chronometer.	Chronometer correction.
1875.	° ′	h. m. s.	h. m. s.	h. m. s.
May 12, a. m.	73 10.8	6 26 35	7 29 39	−1 03 04
12, a. m.	61 32.0	7 25 27	8 29 10	−1 03 43
12, p. m.	68 45.7	5 03 34	6 07 09	−1 03 35
12, p. m.	74 23.1	5 32 20	6 36 03	−1 03 43

POPLAR BLUFF, MO. $\phi = 36° 45'$.

May 17, a. m.	80 38.7	5 45 31	4 17 29	+1 28 02
17, p. m.	50 45.2	3 36 01	2 07 51	+1 28 10

LITTLE ROCK, ARK. $\phi = 34° 46'$.

May 20, a. m.	58 48.8	7 35 16	7 45 57	−0 10 41*

MEMPHIS, TENN. $\phi = 35° 13'.0$.

May 24, p. m.	61 06.8	4 31 09	4 31 02	+0 00 07
24, p. m.	67 40.3	5 03 37	5 03 45	−0 00 08
24, p. m.	72 23.6	5 27 14	5 27 24	−0 00 10
25, a. m.	62 08.0	7 16 47	7 17 04	−0 00 17

CORINTH, MISS. $\phi = 34° 57'$.

May 27, a. m.	70 50.9	6 33 00	6 27 19	+0 05 41
27, a. m.	65 57.5	6 57 21	6 51 39	+0 05 42
27, p. m.	60 25.8	4 29 11	4 23 30	+0 05 41
27, p. m.	64 06.7	4 47 19	4 41 35	+0 05 44

FLORENCE, ALA. $\phi = 34° 47'.2$.

May 29, p. m.	49 09.0	3 35 00	3 26 00	+0 09 00
29, p. m.	58 20.6	4 19 51	4 10 52	+0 08 59
29, p. m.	62 35.8	4 40 47	4 31 55	+0 08 52
29, p. m.	67 03.8	5 02 49	4 53 55	+0 08 54

MADISON, ALA. $\phi = 34° 40'.6$.

May 31, a. m.	78 47.0	5 52 01	5 39 22	+0 12 39
31, a. m.	66 31.1	6 53 50	6 41 08	+0 12 32
31, p. m.	64 29.2	4 50 57	4 38 19	+0 12 38
31, p. m.	69 54.2	5 17 52	5 05 20	+0 12 32

CLEVELAND, TENN. $\phi = 35° 09'.9$.

June 2, p. m.	59 19.1	4 26 44	4 06 29	+0 20 15
2, p. m.	64 03.7	4 50 11	4 30 02	+0 20 09
2, p. m.	70 11.1	5 20 37	5 00 42	+0 19 55
17, p. m.	48 18.2	3 38 14	3 17 45	+0 20 29
17, p. m.	62 31.3	4 48 15	4 27 44	+0 20 31
18, a. m.	61 08.2	7 19 49	6 59 14	+0 20 35
18, a. m.	56 06.7	7 44 30	7 24 01	+0 20 29

* Chronometer set to watchmaker's time at Little Rock.

Observations for Local Time—Continued.

KNOXVILLE, TENN. $\phi = 35° 56'$.

Date.	Corrected Z. D. ⊙.	Mean time of obs'n.	Time by chronometer.	Chronometer correction.
1875.	° ′	*h. m. s.*	*h. m. s.*	*h. m. s.*
June 7, p. m.	64. 10 1	4 53 40	4 29 32	+0 24 08
7, p. m.	68 57. 8	5 17 54	4 53 54	+0 24 00
7, p. m.	73 45. 5	5 42 26	5 18 22	+0 24 04
14, p. m.	58 34. 4	4 28 18	4 03 55	+0 24 23
14, p. m.	63 48. 1	4 54 29	4 30 13	+0 24 16
16, a. m.	78 48. 5	5 48 24	5 24 08	+0 24 16
16, a. m.	72 05. 4	6 23 25	5 59 05	+0 24 20
16, a. m.	67 38. 3	6 46 10	6 21 49	+0 24 21

GUTHRIE, KY. $\phi = 36° 36'.0$.

June 21, p.m.	47 47. 2	3 36 43	3 25 08	+0 11 35
21, p.m.	54 16. 1	4 09 03	3 57 31	+0 11 32
21, p.m.	58 54. 6	4 32 18	4 20 48	+0 11 30
23, a. m.	78 48. 8	5 48 20	5 36 34	+0 11 46
23, a. m.	73 19. 7	6 17 16	6 05 28	+0 11 48
23, a. m.	68 19. 1	6 43 10	6 31 16	+0 11 54

CROFTON, KY. $\phi = 37° 02'.2$.

June 24, a. m.	78 18. 1	5 50 31	5 39 59	+0 10 32
24, a. m.	72 32. 8	6 20 57	6 10 24	+0 10 33
24, a. m.	67 23. 9	6 47 37	6 37 00	+0 10 37
24, p.m.	55 17. 8	4 14 57	4 04 34	+0 10 23
24, p.m.	61 00. 7	4 43 47	4 33 25	+0 10 22
24, p.m.	69 15. 5	5 25 59	5 15 43	+0 10 16

EVANSVILLE, IND. $\phi = 38° 00'.0$.

June 25, p.m,	54 17. 5	4 10 22	4 00 25	+0 09 57
25, p.m.	58 27. 2	4 31 35	4 21 40	+0 09 57
26, a. m.	76 11. 1	6 00 40	5 50 54	+0 09 46
26, a. m.	70 17. 7	6 31 56	6 22 04	+0 09 52
26, a. m.	64 34. 0	7 01 45	6 52 00	+0 09 45

PORTLAND, KY. $\phi = 38° 16'.3$.

June 30, p.m.	54 26. 8	4 11 39	3 36 29	+0 35 10
30, p.m.	60 16. 1	4 41 27	4 06 19	+0 35 08
30, p.m.	66 38. 9	5 14 26	4 39 24	+0 35 02
July 1, a. m.	72 32. 6	6 21 26	5 46 11	+0 35 15
1, a. m.	68 03. 6	6 45 07	6 09 46	+0 35 21

CAVE CITY, KY. $\phi = 37° 10'.0$.

July 1, p. m.	62 20. 7	4 50 17	4 16 49	+0 33 28
1, p. m.	67 49. 8	5 18 20	4 44 57	+0 33 23
2, a. m.	67 29. 9	6 49 35	6 15 20	+0 34 15
2, a. m.	60 43. 4	7 24 09	6 49 50	+0 34 19

NICHOLASVILLE, KY. $\phi = 37° 55'.6$.

July 7, a. m.	77 51. 4	5 56 21	5 17 21	+0 39 00
7, a. m.	71 13. 0	6 31 32	5 52 35	+0 38 57
7, p.m.	61 37. 9	4 47 52	4 08 54	+0 38 58
7, p.m.	69 30. 0	5 28 27	4 49 31	+0 38 56
7, p.m.	75 30. 8	6 00 04	5 21 06	+0 38 58

Observations for Local Time—Continued.

MAYSVILLE, KY. No observations for local time.

HUNTINGTON. W. VA. $\phi = 38° 27'.0$.

Date.	Corrected Z. D. ☉.	Mean time of obs'n.	Time by chronometer.	Chronometer correction.
1875.	° ′	*h. m. s.*	*h. m. s.*	*h. m. s.*
July 13, a. m.	78 52.0	5 53 15	5 06 16	+0 46 59
13, a. m.	72 29.2	6 27 15	5 40 14	+0 47 01
13, a. m.	68 31.2	6 48 04	6 01 00	+0 47 04
13, p. m.	47 59.4	3 37 09	2 50 13	+0 46 56

1876.

OBSERVATIONS FOR DECLINATION.

STATIONS.

Plymouth, Mass.
Lowell, Mass.
Fitchburg, Mass.
Greenfield, Mass.
North Adams, Mass.
Bellows Falls, Vt.
White River Junction, Vt.
Wells River, Vt.
Derby Line, Derby, Vt.
Richmond Junction, Province of Quebec.
Becancour, Province of Quebec.
Saint Thomas, Province of Quebec.
Rivière-au-Loup-en-bas, Province of Quebec.

Observer, F. E. HILGARD.

MAGNETIC SURVEY, 1876.

PLYMOUTH, MASS. $\phi = 41° 58'.0$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
1876.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
July 11, a. m.	69 42.9	78 07.4	191 12.0	113 04.6	360 00.0	246 55.4	....	257 52.6	10 56.6	W.	July 11, a. m.
11, a. m.	64 43.4	82 19.2	195 23.6	113 04.4	360 00.0	246 55.6	....	257 45.9	10 49.9	W.	12, a. m.
11, a. m.	61 02.7	85 26.9	198 29.8	113 02.9	360 00.0	246 57.1	246 56.0	257 54.0	10 58.0	W.	12, p. m.
									10 54.8	W.	

LOWELL, MASS. $\phi = 42° 39'.0$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
July 19, p. m.	75 01.6	75 28.7	269 22.3	344 51.0	101 44.0	116 53.0					
20, a. m.	74 02.6	76 30.0	319 36.2	243 06.2	360 00.0	116 53.8	....	127 38.9	10 45.6	W.	July 19, a. m.
20, a. m.	71 09.1	79 01.7	322 08.0	243 06.3	360 00.0	116 53.7	....	127 46.3	10 53.0	W.	19, p. m.
20, a. m.	68 23.0	81 26.4	324 33.8	243 07.4	360 00.0	116 52.6	116 53.3	127 38.3	10 45.0	W.	20, a. m.
									10 47.9	W.	

FITCHBURG, MASS. $\phi = 42° 35'.0$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
July 21, p. m.	70 59.8	79 32.1	70 02.3	149 34.4	360 00.0	210 25.6					
21, p. m.	73 35.1	77 16.4	72 18.6	149 35.0	360 00.0	210 25.0					
22, a. m.	75 55.7	75 22.1	224 55.9	149 33.8	360 00.0	210 26.2	....	221 10.1	10 44.2	W.	July 22, a. m.
22, a. m.	72 54.0	78 02.0	227 35.2	149 33.2	360 00.0	210 26.8	210 25.9	221 08.9	10 43.0	W.	22, p. m.
									10 43.6	W.	

GREENFIELD, MASS. $\phi = 42° 35'.0$

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
July 24, p. m.	67 59.1	83 01.5	353 53.5	76 55.0	180 00.0	103 05.0	....	113 35.3	10 20.9	W.	July 25, a. m.
24, p. m.	70 24.1	80 54.3	356 01.5	76 55.8	180 00.0	103 04.2	....	113 14.9	10 09.5	W.	25, p. m.
25, p. m.	68 17.1	83 03.4	353 49.5	76 52.9	180 00.0	103 07.1	....	113 26.8	10 21.4	W.	26, a. m.
25, p. m.	71 31.8	80 12.9	356 41.8	76 54.7	180 00.0	103 05.3	103 05.4	113 25.3	10 19.9	W.	26, p. m.
									10 20.2	W.	

Observations for Declination—Continued.

NORTH ADAMS, MASS. $\phi = 42° 42'.0$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠ Mark and mag. meridian.	Decli-nation.	E. or W. of north.	Date of obs'ns for declination.
1876.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
July 28, a. m.	82 06.3	71 34.0	208 56.1	137 22.1	180 00.0	42 37.9					
28, a. m.	77 29.5	75 45.6	213 08.2	137 22.6	180 00.0	42 37.4	....	53 08.1	10 30.9	W.	July 28, p. m.
28, a. m.	75 21.3	77 40.0	215 02.5	137 22.5	180 00.0	42 37.5	....	53 06.3	10 29.1	W.	29, a. m.
28, a. m.	72 57.8	79 46.9	217 10.8	137 23.9	180 00.0	42 36.1	42 37.2	53 09.6	10 32.4	W.	29, p. m.
									10 30.8	W.	

BELLOWS FALLS, VT. $\phi = 43° 09'$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠ Mark and mag. meridian.	Decli-nation.	E. or W. of north.	Date of obs'ns for declination.
Aug. 1, p. m.	63 31.2	89 57.5	232 48.6	322 46.1	360 00.0	37 13.9	....	48 23.9	11 09.6	W.	July 31, m.
1, p. m.	65 48.1	87 50.3	234 55.2	322 45.5	360 00.0	37 14.5	....	48 24.0	11 09.7	W.	31, p. m.
1, p. m.	68 12.0	85 38.9	237 06.5	322 45.4	360 00.0	37 14.6	37 14.3	48 14.7	11 00.4	W.	Aug. 1, a. m.
								48 21.6	11 07.3	W.	1, p. m.
									11 06.7	W.	

WHITE RIVER JUNCTION, VT. $\phi = 43° 41'$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠ Mark and mag. meridian.	Decli-nation.	E. or W. of north.	Date of obs'ns for declination.
Aug. 2, p. m.	59 32.0	94 30.5	162 16.2	256 46.7	360 00.0	103 13.3	....	114 13.8	11 00.3	W.	Aug. 3, a. m.
2, p. m.	61 14.3	92 49.2	163 57.6	256 46.8	360 00.0	103 13.2	....	114 19.5	11 06.0	W.	3, p. m.
2, p. m.	63 02.2	91 04.0	165 41.9	256 45.9	360 00.0	103 14.1	103 13.5	114 19.0	11 05.5	W.	5, a. m.
								114 22.8	11 09.3	W.	5, p. m.
									11 05.3	W.	

WELLS RIVER, VT. $\phi = 44° 09'.0$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠ Mark and mag. meridian.	Decli-nation.	E. or W. of north.	Date of obs'ns for declination.
Aug. 9, a. m.	57 32.0	99 49.5	219 23.4	119 33.9	360 00.0	240 26.1					
9, a. m.	55 37.5	101 57.1	221 29.9	119 32.8	360 00.0	240 27.2					
9, a. m.	53 41.9	104 11.7	223 44.1	119 32.4	360 00.0	240 27.6					
9, a. m.	51 31.1	106 51.1	226 24.1	119 33.0	360 00.0	240 27.0	240 27.0	252 21.5	11 54.5	W.	Aug. 8.

DERBY LINE, DERBY, VT. $\phi = 45° 00'.0$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠ Mark and mag. meridian.	Decli-nation.	E. or W. of north.	Date of obs'ns for declination.
Aug. 10, p. m.	63 48.5	94 22.5	262 24.9	356 47.4	360 00.0	3 12.6					
10, p. m.	66 15.8	91 51.3	264 56.0	356 47.3	360 00.0	3 12.7					
10, p. m.	68 43.7	89 22.9	267 25.1	356 48.0	360 00.0	3 12.0					
11, a. m.	68 46.6	89 35.2	266 20.0	176 44.8	180 00.0	3 15.2	....	16 31.0	13 17.4	W.	Aug. 12, a. m.
11, a. m.	66 00.2	92 23.2	269 07.7	176 44.5	180 00.0	3 15.5	3 13.6	16 32.6	13 19.0	W.	12, p. m.
									13 18.2	W.	

RICHMOND JUNCTION, PROVINCE OF QUEBEC. $\phi = 45° 41'.0$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠ Mark and mag. meridian.	Decli-nation.	E. or W. of north.	Date of obs'ns for declination.
Aug. 16, a. m.	78 53.4	81 53.4	333 31.9	251 38.5	180 00.0	288 21.5					
16, a. m.	76 31.6	84 16.0	335 54.4	251 38.4	180 00.0	288 21.6	....	305 20.8	16 59.5	W.	Aug. 15, a. m.
16, a. m.	73 51.3	86 57.5	338 36.6	251 39.1	180 00.0	288 20.9	288 21.3	305 21.0	16 59.7	W.	15, p. m.
									16 59.6	W.	

BECANCOUR, PROVINCE OF QUEBEC. $\phi = 46° 22'.0$.

Date.	Cor-rected Z. D. ⊙.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠ Mark and mag. meridian.	Decli-nation.	E. or W. of north.	Date of obs'ns for declination.
Aug. 22, a. m.	78 50.5	84 50.1	350 21.9	265 31.8	180 00.0	274 28.2					
22, a. m.	76 13.3	87 33.3	353 05.4	265 32.1	180 00.0	274 27.9	....	290 07.8	15 40.1	W.	Aug. 17, p. m.
22, a. m.	73 27.0	90 27.1	355 59.9	265 32.8	180 00.0	274 27.2	....	290 09.0	15 41.3	W.	18, a. m.
22, a. m.	69 57.6	94 09.6	359 42.2	265 32.6	180 00.0	274 27.4	274 27.7	290 16.8	15 49.1	W.	18, p. m.
									15 43.5	W.	

Observations for Declination—Continued.

SAINT THOMAS, PROVINCE OF QUEBEC. $\phi=46° 59'.0$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
1876.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		
Aug. 24, a. m.	78 29.2	86 17.0	307 45.9	221 28.9	240 00.0	18 31.1	....	36 24.0	17 52.8	W.	Aug. 24, p. m.
24, a. m.	75 54.3	89 01.5	310 30.4	221 28.9	240 00.0	18 31.1	....	36 15.4	17 44.2	W.	25, a. m.
24, a. m.	73 10.0	91 58.3	313 26.9	221 28.6	240 00.0	18 31.4	18 31.2	36 24.5	17 53.3	W.	25, p. m.
									17 50.1	W.	

RIVIÈRE-AU-LOUP-EN-BAS, PROVINCE OF QUEBEC. $\phi=47° 51'.0$.

Date.	Corrected Z. D. ☉.	Azimuth.	Reading of hor. circle.	North reads.	Mark reads.	Azimuth of mark.	Mean azimuth of mark.	∠Mark and mag. meridian.	Declination.	E. or W. of north.	Date of obs'ns for declination.
Aug. 30, a. m.	67 29.4	102 11.4	295 55.1	193 43.7	241 00.0	47 16.3	....	67 59.7	20 43.6	W.	Aug. 28, a. m.
30, a. m.	65 24.3	104 46.2	298 30.4	193 44.2	241 00.0	47 15.8	....	67 58.6	20 42.5	W.	28, p. m.
30, a. m.	63 19.9	107 26.6	301 10.5	193 43.9	241 00.0	47 16.1	47 16.1	67 47.8	20 31.7	W.	29, a. m.
								67 59.5	20 43.4	W.	29, p. m.
								67 48.8	20 32.7	W.	30, a. m.
									20 38.8	W.	

1876.

OBSERVATIONS FOR DIP.

STATIONS.

Plymouth, Mass.
Lowell, Mass.
Fitchburg, Mass.
Greenfield, Mass.
North Adams, Mass.
Bellows Falls, Vt.
White River Junction, Vt.
Wells River, Vt.
Derby Line, Derby, Vt.
Richmond Junction, P. Q.
Becancour, Province of Quebec.
Saint Thomas, Province of Quebec.
Rivière-au-Loup-en-bas, Province of Quebec.
Edmonston, New Brunswick.

Observer, F. E. HILGARD.

MAGNETIC SURVEY, 1876.

PLYMOUTH, MASS.

Date.	Needle.	Polarity north.			Polarity south.			Dip.
		Circle E.	W.	Mean.	Circle E.	W.	Mean.	
1876.		° ′	′	′	° ′	′	′	° ′
July 12, a. m.	1	73 44.0	57.5	50.8	73 41.0	57.3	49.2	73 50.0
12, m.	2	73 45.0	55.5	50.2	73 45.2	41.1	43.1	73 46.7
								73 48.3

LOWELL, MASS.

Date.	Needle.	Circle E.	W.	Mean.	Circle E.	W.	Mean.	Dip.
July 19, a. m.	1	74 24.5	14.7	19.6	74 21.7	05.8	13.7	74 16.6
19, p. m.	2	74 27.1	16.8	21.9	74 25.0	19.5	22.2	74 22.1
								74 19.3

FITCHBURG, MASS.

Date.	Needle.	Circle E.	W.	Mean.	Circle E.	W.	Mean.	Dip.
July 21, p. m.	1	73 86.2	48.0	67.1	73 91.0	49.0	70.0	74 08.5
22, a. m.	2	73 86.2	58.8	72.5	73 81.2	58.5	69.9	74 11.2
								74 09.8

Observations for Dip—Continued.

GREENFIELD, MASS.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
1876.		° ′	′	′	° ′	′	′	° ′
July 24, p. m.	1	73 74.5	45.0	59.8	73 82.8	57.8	70.3	74 05.1
25, a. m.	2	73 75.6	55.0	65.3	73 83.8	54.0	68.9	74 07.1
								74 06.1

NORTH ADAMS, MASS.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
July 28, a. m.	1	74 20.5	29.0	24.8	74 24.8	04.8	14.8	74 19.8
28, p. m.	2	73 81.5	59.5	70.5	74 22.2	00.0	11.1	74 10.8
								74 15.3

BELLOWS FALLS, VT.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
July 31, a. m.	1	74 38.0	14.5	26.2	74 47.5	18.0	32.8	74 29.5
31, p. m.	2	74 42.0	21.3	31.7	74 38.0	18.0	28.0	74 29.9
								74 29.7

WHITE RIVER JUNCTION, VT.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Aug. 4, a. m.	1	75 21.8	10.0	15.9	75 22.0	26.7	24.4	75 20.1
4, p. m.	2	74 59.2	48.2	53.7	74 64.2	50.5	57.3	74 55.5
								75 07.8

WELLS RIVER, VT.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Aug. 7, p. m.	1	75 49.0	27.5	38.2	75 51.8	30.8	41.3	75 39.8
7, p. m.	2	75 50.5	30.8	40.6	75 49.5	34.2	41.9	75 41.2
8, a. m.	1	75 31.0	08.5	19.8	75 39.8	12.2	26.0	75 22.9
8, a. m.	2	75 31.5	10.0	20.8	75 27.8	11.0	19.4	75 20.1
								75 31.0

DERBY LINE, DERBY, VT.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Aug. 11, a. m.	1	75 56.2	46.8	51.5	75 62.2	49.0	55.6	75 53.5
11, a. m.	2	75 51.8	47.2	49.5	75 53.8	49.2	51.5	75 50.5
11, p. m.	1	75 48.5	44.0	46.2	75 58.0	49.0	53.5	75 49.8
11, p. m.	2	75 52.2	46.8	49.5	75 53.0	48.0	50.5	75 50.0
								75 51.0

RICHMOND JUNCTION, PROVINCE OF QUEBEC.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Aug. 15, a. m.	1	75 47.0	39.0	43.0	75 60.2	46.2	53.2	75 48.1
15, a. m.	2	75 45.0	46.2	45.6	75 53.2	45.0	49.1	75 47.4
15, p. m.	1	75 49.5	190.5	120.0	76 03.2	133.8	68.5	(?)
15, p. m.	2	75 47.8	47.8	47.8	75 47.2	43.5	45.4	75 46.6
								75 47.4

BECANCOUR, PROVINCE OF QUEBEC.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Aug. 17, p. m.	1	76 53.0	47.0	50.0	77 07.8	10.2	09.0	76 59.5
17, p. m.	2	76 50.2	49.2	49.7	76 52.5	49.8	51.2	76 50.5
18, a. m.	1	76 53.0	45.8	49.4	76 56.7	70.2	63.5	76 56.4
18, a. m.	2	76 56.0	48.8	52.4	76 54.0	47.5	50.8	76 51.6
								76 54.5

Observations for Dip—Continued.

SAINT THOMAS, PROVINCE OF QUEBEC.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
1876.		° ′	′	′	° ′	′	′	° ′
Aug. 23, p. m.	1	77 05.8	02.0	03.9	77 16.0	11.2	13.6	77 08.7
23, p. m.	2	77 10.0	06.3	08.1	77 11.5	07.0	09.3	77 08.7
24, a. m.	1	77 13.5	10.0	11.8	77 23.8	19.8	21.8	77 16.8
24, a. m.	2	77 15.2	10.0	12.6	77 14.0	11.2	12.6	77 12.6
								77 11.7

RIVIÈRE-AU-LOUP-EN-BAS, PROVINCE OF QUEBEC.

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Aug. 28, a. m.	1	77 44.8	24.2	34.5	77 36.0	30.2	33.1	77 33.8
28, a. m.	2	77 35.0	29.2	32.1	77 31.5	35.2	33.4	77 32.8
28, p. m.	1	77 28.2	18.8	23.5	77 37.5	37.2	37.4	77 30.4
28, p. m.	2	77 29.0	27.2	28.1	77 32.0	32.0	32.0	77 30.0
29, a. m.	1	77 34.8	27.2	31.0	77 39.0	32.8	35.9	77 33.5
29, a. m.	2	77 32.8	31.2	32.0	77 31.5	29.5	30.5	77 31.2
29, p. m.	1	77 35.0	24.0	29.5	77 30.0	34.8	32.4	77 31.0
29, p. m.	2	77 32.5	28.0	30.2	77 30.8	30.0	30.4	77 30.3
								77 31.6

EDMONSTON, NEW BRUNSWICK,

Date.	Needle.	Polarity north. Circle E.	W.	Mean.	Polarity south. Circle E.	W.	Mean.	Dip.
Aug. 31, a. m.	1	77 18.0	28.0	23.0	77 26.5	18.0	22.2	77 22.6
31, a. m.	2	77 17.5	09.5	13.5	77 18.0	20.0	19.0	77 16.2
31, p. m.	1	77 13.2	22.2	17.7	77 22.5	24.5	23.5	77 20.6
31, p. m.	2	77 14.0	10.5	12.2	77 16.5	13.8	15.2	77 13.7
								77 18.3

1876.

OBSERVATIONS FOR HORIZONTAL INTENSITY.

STATIONS.

Plymouth, Mass.
Lowell, Mass.
Fitchburg, Mass.
Greenfield, Mass.
North Adams, Mass.
Bellows Falls, Vt.
White River Junction, Vt.
Wells River, Vt.
Derby Line, Derby, Vt.
Richmond Junction, P. Q.
Becancour, Province of Quebec.
Saint Thomas, Province of Quebec.
Rivière-au-Loup-en-bas, Province of Quebec.
Edmonston, New Brunswick.

Observer, F. E. HILGARD.

Reduction for temperature to be applied to the observed time of 120 vibrations of the collimator magnet.

In Schott's garden, Washington, D. C., the following observations were made:

I. March 25, 1873.—Mean of two observations, $T=468.6155$; $t=37^\circ.35$ F.

II. March 30, 1873.—Mean of two observations, $T=471.4685$; $t=74^\circ.50$ F.

At that time the horizontal intensity was decreasing, consequently the time of 120 vibrations was increasing, the rate of increase being $0^s.00646$ per day. Referring I to the date of II we obtain the following data for March 30:

$$T=468.6478;\quad t=\overset{\circ}{37}.35.$$
$$T=471.4685;\quad t=74.50.$$
$$\Delta T=\ \ 2.8207;\quad \Delta t=37.15.$$

The difference ΔT being a function of T^2 and of Δt, we assume—

$$\Delta T = \varsigma \Delta t T^2,$$

or,

$$\varsigma = \frac{\Delta T}{\Delta t T^2} = 0.00000034372;$$

$$\therefore \Delta T = 0.00000034372\ T^2,\ \Delta t \text{ being} = 1^\circ \text{ F.}$$

By this formula the following table was computed by substituting for T the values given in the first and third columns.

The correction is $= \Delta T\ (t^\circ - 60^\circ \text{ F.})$:

Time of 120 vibrations.	ΔT.	Time of 120 vibrations.	ΔT.
s.	*s.*	*s.*	*s.*
500	0.0859	548	0.1032
507	0.0884	555	0.1059
514	0.0907	562	0.1086
520	0.0929	569	0.1113
527	0.0955	576	0.1140
534	0.0980	583	0.1168
541	0.1006	590	0.1196

OBSERVATIONS FOR INTENSITY.

MAGNETIC SURVEY, 1876.

PLYMOUTH, MASS.

Date.	Time.	Temp.	Time of 120 vibrations.	Red'n to 60° F.	Time of 120 vibrations. Corrected.	Time of 120 vibrations. Washington.	H. Relative.	H. Absolute.
1876.	*h. m.*	°	*s.*	*s.*				
July 12	8 42 a.m.	91.5	531.361	−3.056	528.305			
12	9 45 a.m.	96.0	530.677	−3.492	527.185			
12	9 08 a.m.	84.5	529.543	−2.352	527.191			
12	5 36 p.m.	91.5	533.557	−3.087	530.470			
12	5 54 p.m.	91.5	533.384	−3.087	530.297			
					528.6896	476.8285	0.81343	3.544

LOWELL, MASS.

Date.	Time.	Temp.	Time of 120 vibrations.	Red'n to 60° F.	Corrected.	Washington.	Relative.	Absolute.
July 19	7 27 a.m.	93.0	539.645	−3.300	536.345			
19	7 58 a.m.	94.0	540.078	−3.400	536.678			
19	5 30 p.m.	92.0	539.978	−3.200	536.778			
					536.6003	476.8285	0.78963	3.440

FITCHBURG, MASS.

Date.	Time.	Temp.	Time of 120 vibrations.	Red'n to 60° F.	Corrected.	Washington.	Relative.	Absolute.
July 22	7 42 a.m.	78.0	534.278	−1.764	532.514			
22	8 02 a.m.	79.0	534.812	−1.862	532.950			
22	3 41 p.m.	80.0	534.345	−1.960	532.385			
22	4 16 p.m.	80.0	533.744	−1.960	531.784			
					532.4082	476.8285	0.80211	3.495

GREENFIELD, MASS.

Date.	Time.	Temp.	Time of 120 vibrations.	Red'n to 60° F.	Corrected.	Washington.	Relative.	Absolute.
July 25	7 23 a.m.	76.0	533.277	−1.568	531.709			
25	7 46 a.m.	77.0	533.377	−1.666	531.711			
26	9 46 a.m.	84.0	534.061	−2.352	531.709			
26	10 06 a.m.	83.5	534.345	−2.303	532.042			
					531.7928	476.8285	0.80397	3.503

Observations for Intensity—Continued.

NORTH ADAMS, MASS.

Date.	Time.	Temp.	Time of 120 vibrations.	Red'n to 60° F.	Time of 120 vibrations. Corrected.	Time of 120 vibrations. Washington.	H. Relative.	H. Absolute.
1876.	h. m.	°	s.	s.				
July 28	3 16 p.m.	78.0	533.361	—1.764	531.597			
28	3 31 p.m.	79.0	533.544	—1.862	531.682			
28	3 46 p.m.	80.0	533.061	—1.960	531.101			
29	7 16 a.m.	68.0	531.794	—0.776	531.018			
29	9 41 a.m.	73.0	532.344	—1.274	531.070			
29	10 06 a.m.	75.0	532.877	—1.470	531.407			
					531.3125	476.8285	0.80542	3.509

BELLOWS FALLS, VT.

July 31	3 05 p.m.	82.0	538.945	—2.200	536.745			
31	3 20 p.m.	82.0	538.828	—2.200	536.628			
Aug. 1	9 05 a.m.	76.0	538.578	—1.600	536.978			
					536.7837	476.8285	0.78909	3.438

WHITE RIVER JUNCTION, VT.

Aug. 3	6 45 a.m.	65.5	547.296	—0.566	546.730			
3	7 05 a.m.	70.0	548.179	—1.032	547.147			
3	5 05 p.m.	81.0	550.371	—2.184	548.187			
3	5 24 p.m.	82.0	550.513	—2.288	548.225			
5	7 50 a.m.	78.0	550.479	—1.872	548.607			
					547.7792	476.8285	0.76833	3.348

WELLS RIVER, VT.

Aug. 8	9 15 a.m.	76.0	554.296	—1.688	552.608			
8	9 35 a.m.	78.0	553.779	—1.899	551.880			
8	6 15 p.m.	76.0	552.946	—1.680	551.266			
8	6 35 p.m.	74.0	553.179	—1.470	551.709			
					551.8658	476.8285	0.74655	3.253

DERBY LINE, DERBY, VT.

Aug. 12	9 45 a.m.	79.0	564.080	—2.071	562.009			
12	10 05 a.m.	82.0	563.530	—2.398	561.132			
12	5 05 p.m.	86.0	564.680	—2.834	561.846			
12	5 25 p.m.	86.0	564.547	—2.834	561.713			
					561.6750	476.8285	0.72070	3.140

RICHMOND JUNCTION, PROVINCE OF QUEBEC.

Aug. 15	7 15 a.m.	74.0	557.763	—1.498	556.265			
15	7 35 a.m.	74.0	558.463	—1.498	556.965			
15	5 05 p.m.	78.0	558.313	—1.930	556.383			
					556.5377	476.8285	0.73406	3.198

BECANCOUR STATION, PROVINCE OF QUEBEC.

Aug. 17	5 35 p.m.	72.0	581.015	—1.392	579.623			
17	5 55 p.m.	72.0	581.081	—1.392	579.689			
18	7 05 a.m.	74.0	581.031	—1.624	579.407			
18	7 25 a.m.	78.0	581.265	—2.088	579.177			
					579.4740	476.8285	0.67711	2.950

Observations for Intensity—Continued.

SAINT THOMAS, PROVINCE OF QUEBEC.

Date.	Time.	Temp.	Time of 120 vibrations.	Red'n to 60° F.	Time of 120 vibrations. Corrected.	Washington.	H. Relative.	Absolute.
1876.	h. m.	°	s.	s.				
Aug. 24	5 05 p.m.	75.0	589.632	—1.794	587.838			
24	5 25 p.m.	75.0	589.316	—1.788	587.528			
25	8 05 a.m.	70.0	590.349	—1.196	589.153			
25	8 25 a.m.	70.0	590.349	—1.196	589.153			
					588.4180	476.8285	0.65668	2.861

RIVIÈRE DU-LOUP-EN-BAS, PROVINCE OF QUEBEC.

Date.	Time.	Temp.	Time of 120 vibrations.	Red'n to 60° F.	Corrected.	Washington.	Relative.	Absolute.
Aug. 28	5 25 p.m.	60.0	595.767	0.000	595.767			
28	5 45 p.m.	59.0	596.600	+0.122	596.722			
29	7 05 a.m.	58.0	595.590	+0.244	595.834			
29	7 25 a.m.	59.0	596.350	+0.122	596.472			
29	9 05 a.m.	62.0	596.117	—0.244	595.873			
					596.1336	476.8285	0.63979	2.788

EDMONSTON, NEW BRUNSWICK.

Date.	Time.	Temp.	Time of 120 vibrations.	Red'n to 60° F.	Corrected.	Washington.	Relative.	Absolute.
Aug. 31	8 15 a.m.	60.0	593.510	0.000	593 510			
31	5 05 p.m.	64.0	594.650*	—0.486	594.164*			
					593.7280	476.8285	0.64498	2.810

1876.

GENERAL RESULTS.

STATIONS.

Plymouth, Mass.
Lowell, Mass.
Fitchburg, Mass.
Greenfield, Mass.
North Adams, Mass.

Bellows Falls, Vt.
White River Junction, Vt.
Wells River, Vt.
Derby, Vt.

Richmond Junction, Province of Quebec.
Becancour, Province of Quebec.
Saint Thomas, Province of Quebec.
Rivière-du-Loup-en-bas, Province of Quebec.
Edmonston, New Brunswick.

Observer, F. E. Hilgard.

MAGNETIC SURVEY, 1876.

PLYMOUTH, MASS.

Date.	Declination.	Dip.	Time of 120 vibrations. At —.	At Washington.	Horizontal intensity.
1876.	° ′	° ′	s.	s.	
July 12	10 56.6 W.	73 50.0	528.30		
	10 49.9 W.	73 46.7	527.18		
	10 58.0 W.	....	527.19	476.83	
			530.47		
			530.30		
	10 54.8 W.	73 48.3	528.69	....	3.544

*To this observation the weight ½ is to be given.—L.

General Results—Continued.

LOWELL, MASS.

Date.	Declination.	Dip.	Time of 120 vibrations. At ——.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1876.	° ′	° ′	s.	s.	
July 19	10 45.6 W.	74 16.6	536.34		
	10 53.0 W.	74 22.1	536.68		
	10 45.0 W.	....	536.78	476.83	
	10 47.9 W.	74 19.3	536.60	....	3.440

FITCHBURG, MASS.

July 22	10 44.2 W.	74 08.5	532.51		
	10 43.0 W.	74 11.2	532.91		
			532.38	476.83	
			531.78		
	10 43.6 W.	74 09.8	532.40	....	3.495

GREENFIELD, MASS.

July 25	10 29.9 W.	74 05.1	531.71		
	10 09.5 W.	74 07.1	531.71		
	10 21.4 W.	....	531.71	476.83	
	10 19.9 W.	....	532.04		
	10 20.2 W.	74 06.1	531.79	....	3.503

NORTH ADAMS, MASS.

July 28	10 30.9 W.	74 19.8	531.60		
	10 29.1 W.	74 10.8	531.68		
	10 32.4 W.	....	531.10	476.83	
			531.02		
			531.07		
			531.41		
	10 30.8 W.	74 15.3	531.31	....	3.509

BELLOWS FALLS, VT.

July 31	11 09.6 W.	74 29.5	536.75		
	11 09.7 W.	74 29.9	536.63		
	11 00.4 W.	....	536.98	476.83	
	11 07.3 W.				
	11 06.7 W.	74 29.7	536.79	....	3.438

WHITE RIVER JUNCTION, VT.

Aug. 3	11 00.3 W.	75 20.1	546.73		
	11 06.0 W.	74 55.5	547.15		
	11 05.5 W.	....	548.19	476.83	
	11 09.3 W.	....	548.22		
			548.61		
	11 05.3 W.	75 07.8	547.78	....	3.348

WELLS RIVER, VT.

Aug. 8	11 54.5 W.	75 39.8	552.61		
		75 41.2	551.88		
		75 22.9	551.27	476.83	
		75 20.1	551.71		
	11 54.5 W.	75 31.0	551.87	....	3.253

General Results—Continued.

DERBY LINE, DERBY, VT.

Date.	Declination.	Dip.	Time of 120 vibrations. At ——.	Time of 120 vibrations. At Washington.	Horizontal intensity.
1876.	° ′	° ′	s.	s.	
Aug. 12	13 17.4 W.	75 53.5	562.01		
	13 19.0 W.	75 50.5	561.13		
		75 49.8	561.85	476.83	
		75 50.0	561.71		
	13 18.2 W.	75 51.0	561.67	....	3.140

RICHMOND JUNCTION, PROVINCE OF QUEBEC.

Aug. 15	16 59.5 W.	75 48.1	556.27		
	16 59.7 W.	75 47.4	556.96		
			556.38	476.83	
	16 59.6 W.	75 47.7	556.54	....	3.198

BECANCOUR, PROVINCE OF QUEBEC.

Aug. 18	15 40.1 W.	76 59.5	579.62		
	15 41.3 W.	76 50.5	579.69		
	15 49.1 W.	76 56.4	579.41	476.83	
		76 51.6	579.18		
	15 43.5 W.	76 54.5	579.47	....	2.950

SAINT THOMAS, PROVINCE OF QUEBEC.

Aug. 24	17 52.8 W.	77 08.7	587.84		
	17 44.2 W.	77 08.7	587.53		
	17 53.3 W.	77 16.8	589.15	476.83	
		77 12.6	589.15		
	17 50.1 W.	77 11.7	588.42	....	2.861

RIVIÈRE-DU-LOUP-EN-BAS, PROVINCE OF QUEBEC.

Aug. 28	20 43.6 W.	77 33.8	595.77		
	20 42.5 W.	77 32.8	596.72		
	20 31.7 W.	77 30.4	595.83	476.83	
	20 43.4 W.	77 30.0	596.47		
	20 32.7 W.	77 33.5	595.87		
		77 31.2			
		77 31.0			
		77 30.3			
	20 38.8 W.	77 31.6	596.13	....	2.788

EDMONSTON, NEW BRUNSWICK.

Aug. 31	....	77 22.6	593.51		
		77 16.2	*594.16	476.83	
		77 20.6			
		77 13.7			
		77 18.3	593.73	....	2.810

* To this observation the weight ½ is to be given.

SUMMARY OF RESULTS, 1871 *TO* 1876.

No.	Station.	Lat.	Long.	Date of occupation.	Declination.	Dip.	Hor. intensity.	Notes as to locality, &c.
		° ′	° ′		° ′	° ′		
1	Columbus, Ohio	39 58	83 00	1871, Nov. 18 to 20.	East 1 12.8†	....	....	State-house grounds.
2	Richmond, Ind.	39 50	84 50	1871, Nov. 24	East 3 16.1	71 26.6	....	In the garden of Dr. Plummer, No. 31 Front st.
3	New Albany, Ind	38 20	85 47	1871, Nov. 28	....	70 21.9	4.466	On hill on Paola road, in negro grave-yard. Sandstone formation.
4	Edgefield, Tenn	36 15	86 46	1871, Dec. 1	East 5 02.0	67 10.7	4.478	In middle of SW. quarter of grounds in front of Settle's estate, now St. Alban's.
5	Corinth, Miss	34 56	88 35	1871, Dec. 3	East 5 49.9	65 54.6	5.248	On low ground, in an inclosed pasture NW. of junction, between old forts.
6¹	Oxford, Miss	34 22	89 32	1871, Dec. 24	....	65 03.4	5.444	On flat hill top (base-ball grounds) south of campus of university.
6²	......do	34 22	89 32	1872, May 15	....	65 05.3	5.408	Do.
7	Grenada, Miss	33 47	89 50	1872, Mar. 20	East 6 25.1	64 24.0	5.510	NW. of town, beyond sand ravines, SE. of J. S. Ladd's property.
8*	Magnolia Base, La.	29 32	89 47	1872, Jan. 20	East 6 46.8	59 23.5	5.977	This is the Magnolia Base of the U. S. Coast Survey.
9	New Orleans, La.:							
	City Park station	29 57	90 03	1872, Feb. 12	East 6 39.8	59 43.5	5.959	City Park.
	Fair Grounds stat'n	29 57	90 03	1872, Feb. 14	East 6 39.5	59 48.6	....	Fair grounds, "Wet Pasture."
10	South West Pass, La.	28 59	89 23	1872, Mar. 2	East 6 05.4	58 46.5	6.209	On island west of Stake I'd, about four feet above water. [Result at second station doubtful.]
11*	Osgood's Island, La	20 11	89 05	1872, Mar. 5	East 6 10.7	59 01.2	6.068	Island is the property of George Osgood, and is SE. by E. of Pass à l'Outre Light-House.
12	Avery's Island, La	29 55	91 45	1872, Mar. 15	East 7 19.7	59 26.4	6.012	Island is 6 or 7 miles SW. of New Iberia. Station SE. of mansion, marked by a quartz stone.
13	Brashear City, La	29 41	91 14	1872, Mar. 23	East 6 53.1	59 16.3	6.093	North of town a few blocks above R. R. depot. Station in old earthworks.
14	Baton Rouge, La	30 26	91 12	1872, Apr. 4	East 6 59.5	60 20	6.008	Station is on a mound south of college, marked by a marble rock.
15	Grand Ecore, La	31 48	93 07	1872, Apr. 10	East 7 52.4	61 27.2	5.901	Station marked by a flagstone in a semicircular breast-work in front of Dr. J. S. Collier's hotel.
16	Shreveport, La	32 30	93 45	1872, Apr. 14	East 8 00.1	62 04.4	5.809	On river front of Jones Hill, lower end, marked by a sandstone.
17	Longview, Tex	32 29	94 34	1872, Apr. 15	East 8 37.8	61 57.6	5.790	In an open space north of depot, marked by a dark-colored sandstone.
18	Alexandria, La	31 17	92 27	1872, Apr. 17	East 7 43.9	60 53.0	5.965	In "Irwin's pasture," in rear of Catholic church, marked by a brick stone set into the levee.
9	Natchez, Miss	31 34	91 24	1872, Apr. 22	East 7 14.8	61 26.7	5.874	On bluff at north end of town, opposite Jewish burying ground.
20	Vicksburg, Miss	32 21	90 53	1872, Apr. 24	East 7 27.2	62 28.4	5.749	On Castle Hill, south end of bluff, east of school-house, and marked by a brick stone.
21	Monroe, La	32 29	92 08	1872, Apr. 26	East 7 35.5	....	5.778	
22	Jackson, Miss	32 19	90 12	1872, Apr. 28	East 7 20.5	....	5.665	On a bald spot, in rear of Free School, NE. of State-house.
23	Memphis, Tenn	35 09	90 03	1872, May 21	....	65 37.5	5.296	
24	Golconda, Ill	37 23	88 25	1871, Aug. 31 to Oct. 13.	....	68 03.1	....	
	......do	37 23	88 25	1872, June 6	East 6 05.8	67 55.9	4.885	
25	Cairo, Ill	37 00	89 10	1872, June 22	....	67 41.3	4.914	
26¹	Saint Louis, Mo	38 38	90 12	1872, June 24 to July 9.	East 6 35.2	69 34.4	4.607	First station on the premises of Julius Pitzman, 1900 S. Compton avenue.
	......do	....	....	1872, Nov. 24	....	....	4.651	Do.
26²	......do	....	....	1872, July 12	East 6 48.9	....	....	Second station in street adjoining Pitzman's field. In meridian of the first station.
26³	......do	....	....	1872, Aug. 3 to Aug. 10.	East 6 39.9	....	....	Third station is in empty lot, about 7,000 feet south and 5,000 feet west of court-house.

NOTE.—Slight changes have been made in the geographical positions of stations marked with an asterisk (*) in order to make them conform to the revised positions given in Assistant Schott's paper, Appendix No. 13.

† Mean of two results adopted.

Summary of Results, 1871 *to* 1876—Continued.

No.	Station.	Lat.	Long.	Date of occupation.	Declination.		Dip.	Hor. intensity.	Notes as to locality, &c.
		° ′	° ′			° ′	° ′		
27	Dubuque, Iowa	42 30	90 45	1872, Aug. 24 to Aug. 27.	East	7 33.6	73 06.8	3.933	On Seminary Hill, on the estate of Geo. D. Wood.
28	Wenona, Ill	41 05	89 26	1872, Aug. 30	East	6 06.1	71 43.9	4.241	Station marked by stone set on premises of J. R. Cowen, five blocks west of Ill. Cent. R. Rd.
29	Macon, Ill	39 42	89 10	1872, Sept. 1	East	5 21.5	70 13.5	4.475	On granite boulder in pasture east of premises of R. H. Woodcock.
30	Highland, Ill	38 45	89 41	1872, Sept. 3	East	6 34.2	69 47.2	4.626	On an old corner-stone on commons south o depot.
31	Hermann, Mo	38 42	91 27	1872, Sept. 29	East	8 13.8	69 21.3	4.666	On hilltop SE. of depot, west of Klink's and southeast of Plust's Hill.
32	Sedalia, Mo	38 42	93 13	1872, Oct. 2	East	8 16.9	68 48.5	4.780	In Geo. Husman's nursery grounds, three quarters of a mile south of depot.
33	Kansas City, Mo	39 05	94 38	1872, Oct. 4	East	10 36.8	69 05.3	4.773	
34	Manhattan, Kans	39 12	96 35	1872, Oct. 7	East	10 51.3	68 47.2	4.773	In College grounds east of main building.
35	Ellis, Kans	38 56	99 40	1872, Oct. 10	East	12 24.9	67 51.7	4.934	
36	Salina, Kans	39 30	97 39	1872, Oct. 9	East	12 47.9	....	....	
37	Wallace, Kans	38 55	101 35	1872, Oct. 12	East	13 17.9	67 31.6	4.956	
38	Denver, Colo	39 45	105 00	1872, Oct. 15	East	14 44.7	67 34.4	4.945	On "Gen'l Pierce's Block," owned by L. F. Barteler, esq.
39	Pueblo, Colo	38 12	104 37	1872, Oct. 17	East	13 55.5	66 38.3	5.124	
40	Cheyenne, Wyo	41 05	104 49	1872, Oct. 22	East	15 26.7	68 58.1	4.705	
41	Sidney, Nebr	41 08	102 55	1872, Oct. 25	East	14 36.9	69 23.9	4.640	
42	North Platte, Nebr	41 11	100 45	1872, Oct. 26	East	13 07.5	69 41.1	4.585	
43	Grand Island, Nebr	40 55	98 23	1872, Oct. 27	East	13 13.5	70 15.5	4.535	In northwest corner of slaughter yard, three-quarters of a mile N.W. of depot.
44	Omaha, Nebr	41 16	95 56	1872, Oct. 31	East	10 44.2	71 06.1	4.320	On hilltop southwest of Brownell school.
45	Des Moines, Iowa	41 35	93 37	1872, Nov. 4	East	9 48.8	71 30.4	4.228	In lot of Judge P. M. Casaday, on Chestnut street, between 5th and 6th streets.
46	Martinsburg, W. Va	39 27	77 57	1873, July 10	West	2 51.7	71 25.1	4.231	In the grounds of Jas. F. Randolph, east of the house.
47	Strasburg, Va	38 58	78 22	1873, July 12	West	2 16.4	70 56.2	4.375	On the grass south side of Queen street, opposite the house of J. M. Kelley.
48*	Culpeper, Va	38 28	78 00	1873, July 14	West	2 21.1	70 42.0	4.492	In pasture belonging to Peter Kelly, 42 paces west by south of cedar tree.
49	Charlottesville, Va	38 01	78 31	1873, July 16	West	1 17.0	70 20.0	4.428	In pasture belonging to S. Ficklin, 17 paces SE. of first clump of cedar trees.
50	Lynchburg, Va	37 25	79 09	1873, July 20	West	0 33.7	69 45.3	4.646	On top of bluff owned by Mr. Lynch, opposite freight station, and ten paces east of cabin.
51	Burkeville, Va	37 13	78 12	1873, July 23	West	1 59.7	69 20.4	4.609	Station known to Mr. Bardwell, C. E. It is 18 paces NW. of Patrick Robinson's fence.
52	Danville, Va	36 37	79 20	1873, July 26	West	1 16.3	68 54.8	4.727	Marked by a stub on Clayburn's Hill, on north side of Dan River.
53	Greensboro', N. C	36 04	79 40	1873, July 28	East	0 43.0	68 35.3	4.901	In the grounds of Mr. Colwell, on Gaston street, above Green.
54*	Salisbury, N. C	35 40	80 20	1873, July 30	East	0 52.1	67 46.0	5.021	In the pasture of J. K. Burk, on Main street, just out of town, going west.
55	Charlotte, N. C	35 14	80 40	1873, Aug. 1	East	1 03.9	67 07.5	5.089	In front yard of Mr. Reidiger, NE. corner of Church and 6th streets.
56*	Morganton, N. C	35 47	81 30	1873, Aug. 5	East	1 11.0	67 15.3	5.067	In front lawn of Major J. W. Wilson's dwelling, opposite the Episcopal church.
57	Asheville, N. C	35 35	82 30	1873, Aug. 7	East	1 58.2	67 26.7	5.078	In grounds attached to the Eagle Hotel, 5 paces west of east wall, and 3 paces north of south wall.
58*	Knoxville, Tenn	35 57	83 56	1873, Aug. 11	East	1 52.6	66 55.3	5.093	In the grounds of the Asylum for the Deaf and Dumb, 3 paces SE. of large tree in front of director's house.
59	Williamsburg, Ky	36 47	84 10	1873, Aug. 14	East	2 04.0	68 25.7	4.933	Marked by a stub 10 paces SW. of SW. corner of court-house. Known to county surveyor.
60	Rogersville, Tenn	36 25	83 03	1873, Aug. 18	East	1 49.0	68 26.2	4.982	In the garden of Capt. F. A. Butler, landlord of the Rogerville House.

NOTE.—Slight changes have been made in the geographical positions of stations marked (*) in order to make them conform to the revised positions given in Assistant Schott's paper, Appendix No. 13.

Summary of Results, 1871 *to* 1876—Continued.

No.	Station.	Lat.	Long.	Date of occupation.	Declination.		Dip.	Hor. intensity.	Notes as to locality, &c.
		° ′	° ′			° ′	° ′		
61*	Bristol, Tenn	36 36	82 11	1873, Aug. 20	East	1 19.5	68 11.0	4.900	In Mr. Jameson's lot, on the spot occupied by the Eclipse party.
62*	Mount Airy, Va	36 52	79 06	1873, Aug. 21	East	0 55.2	68 54.7	4.793	In front yard of Mr. Buck's residence, 13 paces from the west fence; 9 paces from north fence.
63*	Christiansburg, Va	37 11	80 18	1873, Aug. 23	East	0 34.5	69 01.1	4.717	In front yard of Captain Schaeffer, back of colored Baptist church, 14 paces from west fence; 8 from the north walk.
64	Natural Bridge, Va	37 35	79 22	1873, Aug. 26	West	0 04.7	69 42.9	4.602	SE. 3 paces of NE. cedar tree, in the grove on hill-side in front of the hotel.
65	Covington, Va	37 49	79 55	1873, Aug. 28	West	0 22.1	69 47.3	4.584	In the garden of the McCurdy House, 7 paces from the east fence, and 10 from the north fence.
66*	Staunton, Va	38 09	79 04	1873, Sept. 1	West	0 45.6	69 54.1	4.489	U. S. Coast Survey station on the hill over the railroad.
67	Harrisonburg, Va	38 25	78 52	1873, Sept. 2	West	1 28.0	70 28.9	4.437	In front yard of Mr. W. B. Compton, W. Market street, 16 paces north of front fence, and 12 paces west of east fence.
68	York, Pa	39 58	76 44	1874, July 11	West	3 57.8	71 54.5	4.182	In field belonging to Mr. Small, on west bank of river, between the first two of the three trees in the lot.
69	Altoona, Pa	40 30.6	78 25	1874, July 16	West	2 47.0	72 21.7	4.120	In field belonging to the Pennsylvania R. R. Co., and known to Mr. Dixon, the farmer.
70	Williamsport, Pa	41 15	77 03	1874, July 20	West	4 50.2	72 47.5	4.003	In a field belonging to Mr. Herdic, west of Mr. Woodward's house.
71*	Bath, N. Y	42 21	77 21	1874, July 24	West	5 34.4	74 15.5	3.724	In a field belonging to Judge Runsey, 30 paces west of two oak trees standing close together.
72	Rochester, N. Y	43 08	77 40	1874, July 29	West	5 17.8	74 38.5	3.632	In the campus of the university, on grass plat SE. of college.
73	Niagara Falls, N. Y	43 04	79 04	1874, July 31	West	3 37.1	74 37.7	3.646	On a lot belonging to G. W. Holley, and 20 paces west of only tree in lot.
74	Mayville, N. Y	42 16	79 40	1874, Aug. 4	West	2 15.0	74 05.0	3.733	In the grounds of the public school on the hill; between four trees near the south fence.
75	Sharpsville, Pa	41 17	80 27	1874, Aug. 1 to 2.	....	....	72 50.7	4.002	[A large discrepancy, not satisfactorily accounted for, exists between the results for Declination at the two stations.]
76*	Beaver, Pa	40 44	80 16	1874, Aug. 11	West	1 08.2	72 31.5	4.056	In field belonging to Mr. De Vaux, near the river.
77	Greenfield, Pa	40 06	79 52	1874, Aug. 13	West	2 02.2	71 58.9	4.185	In a field of Mr. Gregg, near Johnston's tavern.
78	Tuscarawas, Ohio	40 24	81 50	1874, Aug. 17	West	0 19.7	72 08.5	4.146	In a field of Mr. J. Blickensdorfer, at Trenton station, on railroad.
79	Columbus, Ohio	39 57	82 59	1874, Aug. 19	East	1 12.1	70 59.7	4.359	In the grounds of the blind asylum.
80	Forest, Ohio	40 50	83 28	1874, Aug. 21	East	2 18.3	72 20.7	4.108	In the woods south of the town.
81*	Fort Wayne, Ind	41 06	85 03	1874, Aug. 24	East	2 29.1	72 19.0	4.218	In the fair grounds in western part of town, under the tree nearest the half-mile course.
82	Reynolds, Ind	40 45	86 48	1874, Aug. 27	East	3 30.3	72 00	4.212	In a field of Mr. Van Voerst.
83	Terre Haute, Ind	39 28	87 20	1874, Aug. 29	East	4 34.2	70 34.7	4.505	In a field belonging to Mr. Whitaker, in the prolongation of Fourth street.
84	Fernandina, Fla	30 41	81 28	1875, May 14	East	2 55.3	....	....	Near the Coast Survey station of 1857, and 10 paces from SW. extremity of lot on which Mr. Rue's house stands.
85	Lake City, Fla	30 11	82 37	1875, May 15	East	3 20.4	....	....	On eastern extremity of triangular lot in front of Cothey House; 12 paces from fence on north side of road.
86*	Tallahassee, Fla	30 26	84 17	1875, May 18	East	3 41.7	....	....	In vacant lot on NE. corner of Adams and Pensacola streets, 40 paces from Pensacola street and 15 paces from Adams street (outer edges of sidewalks).

NOTE.—Slight changes have been made in the geographical positions of stations marked (*), in order to make them conform to the revised positions given in Assistant Schott's paper, Appendix No. 13.

Summary of Results, 1871 *to* 1876—Continued.

No.	Station.	Lat.	Long.	Date of occupation.	Declination.	Dip.	Hor. intensity.	Notes as to locality, &c.
		° ′	° ′		° ′	° ′		
87	Saint Mark's, Fla	30 08	84 11	1875, May 18	East 4 30.3	....	....	In lot in front of the United States signal station.
88*	Eufaula, Ala	31 54	85 08	1875, May 22	East 4 33.0	....	....	On the first street west of the railroad, and nearly due west of the old magnetic station on Forsyth street. This station is now lost.
89*	Montgomery, Ala	32 23	86 18	1875, May 24	East 4 38.8	....	....	
90	Evergreen, Ala	31 26	87 05	1875, May 25	East 5 31.9	....	....	On a hill on east side of railroad, in a lot next to Mr. Merten's house, 15 paces from the fence.
91*	Mobile, Ala	30 42	88 03	1875, May 27	East 6 07.0	....	....	In part of city known as Summerville, and in an old fort west of Saint Mary's church.
92	Pascagoula, Miss	30 21	88 33	1875, May 28	East 6 19.5	....	....	
93	Vicksburg, Miss	32 21	90 53	1875, June 3	East 7 19.0	....	....	Dr. Hilgard's station of 1872 on Castle Hill reoccupied.
94	Jackson, Miss	32 19	90 12	1875, June 4 to 5.	East (7 47.2†)	....	....	Dr. Hilgard's station of 1872 reoccupied. In rear of Free School, NE. of State-house.
95*	West Point, Miss	33 33	88 38	1875, June 7	East 6 25.5	....	....	In center of large vacant lot back of Jackson House, and south of court-house.
96	Meridian, Miss	32 20	88 44	1875, Aug. 8	East 6 26.0	....	....	In a lot on Main street, west of the Chattanooga railroad shops.
97*	Tuscaloosa, Ala	33 12	87 40	1875, June 8 to 9.	East 6 04.7	....	....	In the grounds of the University of Alabama. In the meridian, and 20 yards south of the observatory transit.
98	Birmingham, Ala	33 32	86 53	1875, June 10	East 4 26.1	....	....	In a lot NE. of the new court-house.
99*	Selma, Ala	32 25	87 05	1875, June 11	East 4 32.2	....	....	In a lot known as the "old arsenal lot," on west side of river, east of Alabama and south of Union streets; 10 paces from edge of bluff.
100*	Opelika, Ala	32 40	85 25	1875, June 12	East 4 31.8	....	....	On lot adjoining Presbyterian church, Tallapoosa street, and 30 paces from church, in a line with the front.
101*	Macon, Ga	32 50	83 38	1875, June 14	East 3 29.0	....	....	West 12 paces of a former Coast Survey station, marked by a stone post, U. S. C. S.
102*	Milledgeville, Ga	33 04	83 10	1875, June 15	East 4 14.1	....	....	In the old capitol grounds, in the center of a raised terrace of earth.
103*	Lumber City, Ga	31 57	82 45	1875, June 17	East 3 10.8	....	....	In a lot belonging to Colonel Boyd, about one-fourth mile north of railroad station.
104*	Millen, Ga	32 50.5	81 50	1875, June 22	East 2 37.3	....	....	In open lot, 35 paces SW. of corner of building used as a Masonic lodge.
105	Columbia, S. C	34 00	81 02	1875, June 23	East 1 49.3	....	....	On SW. corner of Capitol Square, about 20 paces from fence.
106*	Florence, S. C	34 12	79 44	1875, June 25	East 1 12.2	....	....	On Coit street, about 600 yards from railroad, 25 paces SE. of old African church, on a line with the sidewalk.
107*	Goldsborough, N. C	35 25	77 50	1875, June 28	West 0 15.1	....	....	In a lot on SE. corner of John and Spruce streets, 30 paces from sidewalk on Spruce street, and 30 paces from John street.
108*	Weldon, N. C	36 27	77 25	1875, June 29	West 1 40.7	....	....	In lot west of Methodist church, 15 paces NW. of Mrs. Allen's fence.
109	Wilmington, Del	39 47	75 33	1875, July 1	West 4 07.3	....	....	At the NW. corner of Fourth and Brown streets, at the corner-stone of the streets.
110	Lebanon, Mo	37 38	92 40	1875, July 12	East 8 16.1	....	....	
111	Poplar Bluff, Mo	36 45	90 22	1875, July 17	East 7 12.5	....	....	
112	Little Rock, Ark	34 46	92 15	1875, July 18 to 20.	East 8 10.6	....	....	
113	Memphis, Tenn	35 13	90 03	1875, May 24 to 25.	East 7 01.9	....	....	

NOTE.—Slight changes have been made in the geographical positions of stations marked (*), in order to make them conform to the revised positions given in Assistant Schott's paper, Appendix No. 13.

† This result for declination is about 27′ greater than that of 1872.

Summary of Results, 1871 *to* 1876—Continued.

No.	Station.	Lat.	Long.	Date of occupation.	Declination.	Dip.	Hor. intensity.	Notes as to locality, &c.
		° ′	° ′		° ′	° ′		
114	Corinth, Miss	34 56	88 35	1875, May 27	East 6 21.6	....	....	
115*	Florence Ala	34 47	87 46	1875, May 29	East 5 14.4	....	....	
116*	Madison, Ala	34 41	86 48	1875, May 31	East 5 11.6	....	....	
117*	Cleveland, Tenn	35 10	85 00	1875, June 17 to 18.	East 3 15.3†	....	....	
118*	Knoxville, Tenn	35 56	83 56	1875, June 7	East 1 39.6‡	....	....	
119*	Guthrie, Ky	36 38	87 20	1875, June 21 to 23.	East 6 43.8	....	....	
120*	Crofton, Ky	37 02	87 40	1875, June 24	East 6 15.7	....	....	
121	Evansville, Ind	38 00	87 30	1875, June 25 to 26.	East 6 09.4	....	....	
122*	Portland, Ky	38 16	85 55	1875, June 30 to July 1.	East 3 37.9	....	....	
123*	Cave City, Ky	37 10	85 55	1875, July 1 to 2.	East 5 54.5	....	....	
124*	Nicholasville, Ky	37 56	84 38	1875, July 7	East 2 48.3	....	....	
125	Maysville, Ky	38 41	83 41	1875, July 9 to 10.	East 0 00.4	....	....	
126	Huntington, W. Va	38 27	82 30	1875, July 13	East 0 47	....	....	
127	Plymouth, Mass	41 58	70 39	1876, July 11 to 12.	West 10 54.8	73 48.3	3.544	
128	Lowell, Mass	42 39	71 20	1876, July 19 to 20.	West 10 47.9	74 19.3	3.440	
129	Fitchburg, Mass	42 35	71 48	1876, July 22	West 10 43.6	74 09.8	3.495	
130	Greenfield, Mass	42 35	72 35	1876, July 25 to 26.	West 10 20.2	74 06.1	3.503	
131	North Adams, Mass	42 42	73 07	1876, July 28 to 29.	West 10 30.8	74 15.3	3.509	
132	Bellows Falls, Vt	43 09	72 28	1876, July 31 to Aug. 1.	West 11 06.7	74 29.7	3.438	
133	White River Junction, Vt.	43 41	72 16	1876, Aug. 3 to 5.	West 11 05.3	75 07.8	3.348	
134	Wells River, Vt	44 09	72 05	1876, Aug. 8	West 11 54.5	75 31.0	3.253	
135	Derby, Vt	45 00	72 12	1876, Aug. 12	West 13 18.2	75 51.0	3.140	
136	Richmond Junction, Province of Quebec.	45 41	72 03	1876, Aug. 15	West 16 59.6	75 47.7	3.198	
137	Becancour, Province of Quebec.	46 22	71 33	1876, Aug. 17 to 18.	West 15 43.5	76 54.5	2.950	
138	Saint Thomas, Province of Quebec.	46 59	70 33	1876, Aug. 24 to 25.	West 17 50.1	77 11.7	2.861	
139	Rivière-du-Loup-en-Bas, Province of Quebec.	47 51	69 25	1876, Aug. 28 to 30.	West 20 38.8	77 31.6	2.788	
140	Edmonston, New Brunswick.	47 15	68 20	1876, Aug. 31	....	77 18.3	2.810	

NOTE.—Slight changes have been made in the geographical positions of stations marked (*), in order to make them conform to the revised positions given in Assistant Schott's paper, Appendix No. 13.

† Mean of the two results given.

‡ Result at first station adopted; that at second station discarded as improbable. Compare result at Knoxville in 1873.

APPENDIX No. 15.

COMPARISON OF THE SURVEY OF DELAWARE RIVER OF 1819, BETWEEN PETTYS AND TINICUM ISLANDS, WITH MORE RECENT SURVEYS.

By HENRY L. MARINDIN, Assistant.

UNITED STATES COAST AND GEODETIC SURVEY,

Boston, Mass., March 2, 1882.

SIR: I have the honor to send you the following report on a comparison of a survey of the Delaware River of 1819 with the more recent surveys of the Coast and Geodetic Survey.

In a report dated November 15, 1880,* I had already given a comparison of a number of cross-sections from the surveys of 1843 and 1878; some of these I have compared also with the plan of 1819, and add a number of sections covering the space from the upper end of Pettys Island (named *Pettits* Island on the plan of 1819) to the head of Tinicum Island.

The survey of 1819, made by David McClure "by order of the Councils" of the city of Philadelphia, appears to be as good a survey as can be found of that date. The distances along shore, and the widths of stream in reaches, agree well, but the absence of meridian lines and parallels of latitude, and of unmistakable points on the shore line, makes the comparison a difficult one, and necessarily limits the points of comparison where a certainty of position can be established.

The first section examined (see sketch 41, section A) lies at the upper limit of the plan of 1819 in the north channel of Pettys Island and over "Richmond Bar," so called in my report of November 15, 1881. Maximum depth on Richmond Bar in 1819 = 19 feet at low water; in 1843 the same maximum depth was found, and in 1878 it was 17 feet. The area of cross-section was 39,020 square feet in 1819. In 1843 the area had been reduced to 32,390 square feet, which gives a loss of about 17 per cent. in twenty-four years. This bar, as such, is not apparent on the plan of 1819; the encroachment up to 1843 seems to have been due to the building of wharves; after that date, although the wharves were not extended, the decrease of area continued in a lesser degree, from 32,390 to 29,980 square feet, or only 7 per cent. in thirty-five years. This decrease of area appears to have been due to other causes than obtained between 1819 and 1843. The wharves remained unaltered and the shore line of the island did not change, so that it is along the bed of the channel that the change must be looked for and where it is found. This shoaling, to my mind, is the indirect effect of dumping dredged material in the vicinity.

The next section examined (sketch 41, section B) is in the south channel of Pettys Island, near its western end. This section is also over a bar lying between the island and Cooper's Point. The area of cross-section was 29,900 square feet in 1819, and in 1843 it had been reduced to 21,390 square feet, a loss of 28 per cent.

In 1878 the area showed a decided increase to 24,330 square feet, or about 13 per cent., and the change for the better, shown as having taken place between 1843 and 1878, appears to have been general throughout this channel. The width of this section, which in 1819 was about 2,600 feet, increased to 2,850 feet in 1843, and decreased slightly between 1843 and 1878. The maximum depth on west-end bar, Pettys Island, south channel, was 20 feet at low water in 1819; in 1843 it had shoaled to 15½ feet, and in 1878 it deepened again to 16 feet.

* Appendix No. 9, Report for 1880.

Our next cross-section (sketch 41, section C) was taken in the main stream between a bulkhead at the foot of Callowhill street, Philadelphia, and a wharf at Cooper's Point, the same as section 16 of 1878. The area of cross-section was 54,950 square feet in 1819, with a width of 3,200 feet. In 1843 the area had not changed materially, being 53,600 square feet, with a width of 3,100 feet, the decrease being only 2 per cent.; but between 1843 and 1878 the wharves were extended on both sides of the river, the greatest encroachment taking place at Cooper's Point. The maximum depth (on section 16 of Physical Hydrography, 1878) was 44 feet in 1819; in 1843 it had deepened to 45 feet, and in 1878 to 47 feet in the channel near the Philadelphia shore.

The area, which in 1843 was 53,600 square feet, was reduced to 48,368 square feet in 1878, a reduction of 10 per cent.; but the width decreased in a larger ratio, from 3,100 to 2,320 feet, in 1878, or about 25 per cent.

The next cross-section examined (sketch 41, section D) is one across both channels of Windmill Island, from the foot of Almond street, across the jetty at the south end of the island, to the Camden shore.

Having been able to locate accurately the position of origin of this cross-section on the plan of 1819, I give a sketch of it (sketch 42). This section, which in 1819 passed across Windmill Island 700 feet above its southern extremity, giving 430 feet as the width of the island—from low water on the west channel to low water on the east channel—and a width of about 125 feet above high water, shows the island to have been reduced to a width of 180 feet at low water in 1843, and to have disappeared entirely in 1878. In 1819 the bulkhead at the foot of what is now Almond street, Philadelphia, was about 120 feet shoreward of the wharf existing there in 1878.* The area of cross-section of the west channel was then 33,150 square feet at low-water stage, with the greatest depths about midway between the wharf and Windmill Island. The width of channel-way was then 1,260 feet. In 1843 the survey shows that a wharf had been built on the Philadelphia side, extending 120 feet from the bulkhead of 1819, while the low-water line of the island had not changed; this reduced the channel width to 1,140 feet. The channel-way proper had, however, shifted towards the Pennsylvania shore, making deeper water along the city front. The area of section decreased slightly, from 33,150 to 33,034 square feet. Between 1843 and 1878 the area of cross-section increased to 34,904 square feet, or 5 per cent. During this interval the southern end of Windmill Island disappeared, and the width of the west channel increased to 1,320 feet by the erosion of the island, while the wharf on the Philadelphia side remained nearly in the same condition. The increase of area is mainly due to the increase of channel depths, which is, to my mind, a consequence of restricting the widths of channel by the extension of the wharves on the city front, and securing the permanency of the water line of the island by bulkheading. With fixed shores, the restoration of area of cross-section can only be effected by the bottom giving way.

On the continuation of this cross-section across the east channel we find the greatest changes. In 1819 the low-water line of the island lay 240 feet east of the present jetty. The navigable channel was then near the Camden shore, with a gradual slope of bottom from the island to the greatest depth (18 feet), 1,500 feet distant, and a width of water-way of 1,900 feet, and a sectional area of 22,200 square feet. In 1843 that part of Windmill Island east of the present jetty had disappeared, and the water-way had become more uniform in depth, with a shoaling on the slope of the Camden shore and a corresponding deepening near the island. The width increased from 1,900 feet in 1819, to 2,010 feet in 1843, and the area also in nearly the same proportion, from 22,200 to 23,400 square feet, or 5 per cent., by the wearing away of the island slope and the more general distribution of navigable depths.

During the thirty-five years between 1843 and 1878 the changes in this channel were more marked; the movement of oscillation about a common point continued, by tilting the bottom up on the Camden shore and depressing it towards the island. The last vestige of solid ground across the island had vanished, and comparatively deep water had obtained close to the now existing jetty off the south point of the island, and where the low-water line existed in 1819 we

* The maximum depth in west channel of Windmill Island was 42 feet in 1819; in 1843 the depth increased to 45 feet, and in 1878 a further increase is found to a depth of 48 feet. In the east channel the maximum depth was 18 feet in 1819, and it had shoaled to 16 feet in 1843; in 1878 the maximum depth was 18¼ feet.

now have 15 feet of water. The decrease in the depth on the Camden side is very marked, for at the place where the greatest depth of channel (18 feet) was found in 1819, the ground is now dry at low water and is 200 feet outside of the then low-water line, giving an approximate shoaling of 18 to 20 feet. The area also decreased from 23,400 to 20,140 square feet, or 18 per cent., by the pushing out of the bank on the Camden shore, notwithstanding the large and general increase of navigable depths. The width of stream diminished from 2,010 to 1,430 feet at low water, which is nearly 28 per cent These changes in the east channel must have been induced by the extension of the Camden wharves, both above and below this section, thus creating a lee under which shoaling took place both during the flow of the flood and the ebb, and also crowding the streams against the island shore.

The next cross-section examined (sketch 41, section E) lies at Kaighn's Point, beginning at the Philadelphia shore, about 2,500 feet below the site of the old navy-yard, and running to the upper corner of the Ice-boat Company's lower wharf. The best location of this cross-section on the plan of 1819 gives the apex of the shoal—the prolongation of the tail of Windmill Island—about 400 feet nearer the Jersey shore than in 1843. Thirty-five years later, in 1878, no change had taken place in the position of this shoal, which brings us to the conclusion that the entire shift took place from 1819 to 1843, during a period when the *régime* of the stream was not disturbed by the occupation of the shores. This does not appear probable, and I must attribute this difference of position in the body of the shoal to errors in the location of the soundings of 1819. This may not affect seriously the area of cross-section for comparison.* In 1819 the area was approximately 57,970 square feet, with a width of 3,700 feet at low-water stage. There were then no wharves on either shore for some distance from the section line. In 1843 a wharf had been built on the Philadelphia side, with a long bulkhead running diagonally across the end of the section line, and a shoaling had begun on the Jersey shore, thus reducing the low-water width to 2,980 feet, or nearly 20 per cent., the area decreased about 4 per cent., to 55,700 square feet, by the extension of the wharf and the shoaling, both of which took place in shoal ground, over flats, which did not reduce the area in proportion to the decrease of width. In 1878 a large extension of the bank had taken place on the Jersey side by the erection of wharves at Kaighn's Point, some of which were pushed out to 19 feet depth, whereas the Philadelphia shore was not occupied 30 feet beyond the low-water line of 1843. These changes reduced the width of water-way to 2,430 feet, or nearly 18 per cent.; but the area of cross-section changed inversely to the width by increasing to 60,745 square feet, or about 8 per cent. in a general increase of depths throughout the section, and a maximum increase of 43 per cent. on the apex of the middle shoal—from 14 feet in 1843 to 20 feet in 1878.

The next cross-section (sketch 41, section F) was chosen over the Greenwich Point middle-ground. The same maximum depth is found in these channels in 1878 as in 1819, namely, about 29 feet in that near the Greenwich Point wharves, and 34 feet in the channel near the Jersey shore. The minimum depth on the middle-ground was about 18 feet in 1819, 18 feet in 1843, and 17 feet in 1878. The survey of 1819 shows this middle-ground—taking the 18 feet curve as the limiting line—as the southern end of the shoal then extending from the south end of Windmill Island, with very nearly the same minimum depth over it as was found in 1843 and in 1878. The width of stream was then 2,430 feet at low water, and the approximate area 55,600 square feet, with natural banks on each shore. In 1843 the width was 2,560 feet, and the area had also increased about 2 per cent. to 57,200 square feet; up to that date the shores remained unoccupied. In 1878 the Greenwich Point coal wharves had been built, reducing the width of stream to 2,200 feet and the area of cross-section to 54,300 square feet, or about 5 per cent.; the bank of the Jersey shore seems to have retreated with the advance of the wharves on the opposite shore, and the bottom does not show any special changes aside from a slight tendency to give way, which may in time give better water on the middle-ground.

The next comparison is that of cross-section No. 37, of the Physical Hydrography of 1878 (sketch 41, section G) lying below Gloucester, at the upper end of the Horse-shoe Shoal. The high water lines do not appear to have shifted since 1819, but the low-water line seems to have pushed.

*In this cross-section the maximum velocity in the channel on the Pennsylvania shore was 24 feet in 1819, 28 feet in 1843, and 32 feet in 1878. In the channel on the Jersey shore the maximum depth was 24 feet in 1819, 30 feet in 1843, and 34 feet in 1878. On the apex of the middle shoal the maximum depth was 12 feet in 1819, 14 feet in 1843, and 20 feet in 1878.

out towards the center of the stream on the Pennsylvania side, and to have remained very nearly stationary on the Gloucester shore. The bed of the stream also shows a shift towards the Pennsylvania shore, the largest change being noted between 1819 and 1843. In 1819 the area of cross-section was 47,545 square feet, with a width of 2,650 feet at low water. In 1843 the width had been reduced from 2,650 feet in 1819 to 2,330 feet, or 12 per cent., and the area had changed inversely from 47,545 square feet to 53,915, or nearly 13 per cent. The channel depth had increased about 9 per cent., with a shift of bed as explained above. In section G the maximum depth in 1819 was 40 feet, in 1843 it was 43 feet, and in 1878 also 43 feet. In 1878 the width was 2,260 feet, and the area remained nearly the same as in 1843, or 53,490 square feet, and the shift of bed of stream had continued to the westward with a corresponding advance of the eastern bank towards the center of the river. It would appear that the shift of bed found here and elsewhere is the effect of the unequal occupation of the shores.

The next section (sketch 41, section H) was chosen over the middle of the Horse-shoe Shoal, on the site of section No. 40 of the Physical Hydrography of 1878. The high-water lines do not show any change since 1819. The low-water line at the mouth of the Back Channel, off the eastern end of League Island, remains about in the same position in 1843 as in 1819. Here the section begins. The area in 1819 was approximately 70,380 square feet, with a low-water width of 5,450 feet. In 1843 the area of cross-section had increased to 74,570 square feet, or about 5 per cent., the width remaining nearly the same. The channel-way proper had shifted towards the Pennsylvania shore, with a notable increase of maximum depth, but if we compare the width of channel for 30 feet draught, we find a decrease of 140 feet, and if the sectional area of channel-way for 18 feet draught is observed, it is found that this area had decreased from 42,500 square feet in 1819 to 37,100 square feet in 1843, or 12 per cent., and that the width for this depth had decreased 300 feet, the *maximum depth* showing a large increase notwithstanding. Section H, maximum depth in channel-way was 34 feet in 1819; in 1843 the maximum depth had increased to 44 feet, and in 1878 the maximum depth was reduced to 40½ feet.

In 1878 the area of cross-section had diminished to 72,450 square feet, or about 3 per cent., and the width had increased from 5,550 feet in 1843 to 5,700 feet in 1878. The channel-way remained essentially in the same position, with a decrease of depth in its deepest portion, and also over the shoalest part of the Horse-shoe Shoal.

The navigable channel for a draught of 18 feet decreased both in width and in area—in width from 1,200 to 1,080 feet and in area from 37,100 to 33,080 square feet, or nearly 24 per cent.

In the next section (sketch 41, section I) chosen in the reach off the front of League Island, near its western end (where in 1819 the island was as yet a piece of marsh bordering on the Schuylkill River, and covered at high tide), I find a great change between 1819 and 1843. The area of cross-section was 58,050 square feet at the time of the first survey, with a low-water width of 3,820 feet. In 1843 the area had increased to 77,900 square feet, or 34 per cent.; this change appears large, but might be accounted for by the artificial extension of that part of League Island, west of its limits of 1819, thus restricting the current of the river to narrower limits. The blind channel near the Jersey shore was then very shallow, and the width of the 6-foot shoal, separating it from the main ship channel, was 775 feet against 200 feet in 1843. The water frontage of the island became much bolder between 1819 and 1843, and continued to deepen up to 1878. The low-water width also increased to 4,080 feet. In section I, the maximum depth in the main ship channel was 30 feet in 1819; in 1843 it was 30 feet, and in 1878 28½ feet. In the blind channel on the Jersey shore the maximum depth was 13 feet in 1819, 23 feet in 1843, and 21 feet in 1878.

In 1878 the area was 72,704 square feet, with a low-water width of 3,930 feet. The area had diminished 6 per cent. by a gradual shoaling along the bottom of the channel-way. The same water remained on the shoal dividing the blind channel on the Jersey shore from the main ship channel.

The next section for comparison (sketch 41, section J) was placed at the southern limit of the survey of 1878, beginning at the low-water line near the wharf at Fort Mifflin, and crossing the pier on which Fort Mifflin light-house stands, thence continuing to the Jersey shore. These points were identified on the plan of 1819. The outline of the fort remained unchanged in 1843.

The pier known as Davis' pier in 1819 does not seem to coincide with the light-house pier, but is close to the position of a similar pier which is shown on the survey of 1843. Whether the accurate position of Davis' pier was obtained in 1819 or not, I am unable to say; but the size of this pier as well as its shape tends to confirm its identity.

In 1819 the area of cross-section was 80,230 square feet, and the low-water width 5,060 feet. The section was divided into two channels by the shoal on which Fort Mifflin light-house stands.

In 1843 the low-water line had advanced some 70 feet at the base of the fort. The main channel between the fort and the light-house had deepened somewhat. The same depth of water obtained on the shoal south of the light-house and in the blind channel near the Jersey shore. The area of cross-section had changed but little, to 81,710 square feet, an increase of only 1 per cent. in twenty-four years, and the low-water width remained nearly the same with a slight increase.

In 1878 the maximum depth in the main channel off the fort was the same as in 1843.* The low-water limits had not altered and the only change to note occurred in the blind channel, which shows a shoaling of 5 feet where the maximum depth was located in 1843, and a tendency to impinge on the Jersey bank. The same depth was found on the light-house shoal as in 1819 and 1843, which is remarkable in view of the well-attested changes on shoals located in or near mid-stream anywhere in the Delaware River. Some changes may be noted in the immediate vicinity of the light-house pier. Already in 1843 the water had become very bold on all sides of the pier, but in 1878 still greater undermining is detected by finding 36 feet of water close to the foot of the pier on its southerly side, and 26 feet close on to the opposite side. This shows the position of the light-house pier to be in a precarious condition, and that it is only a question of time when the pier will have to give way. The area of cross-section increased to 85,010 square feet, or about 4 per cent., in thirty-five years, and the width increased to 5,300 feet.

The above section concludes the comparison with the surveys of 1843 and 1878; the next comparisons will be made with the surveys of 1819, 1842, and 1881.

Not having at hand the original hydrography of that section of the Delaware lying between Fort Mifflin and the upper end of Tinicum Island, the space between the last cross-section compared and the next will be longer than that observed between any two of the previous cross-sections.

The next section (sketch 41, section K) was drawn across the middle of Maiden Island off the upper end of Tinicum Island. (See also sketch 43.)

In 1819 this cross-section, beginning at the low-water line on the Pennsylvania shore, presented three distinct channels; the first channel was the one back of what was then called Martin's Bar, lying below Hog Island; then came the channel between Martin's Bar and Maiden Island, and last, the main ship channel between Maiden Island and the Jersey shore. The aggregate area of cross-section of the three water-ways was 81,550 square feet, with a combined width of 4,200 feet. Maiden Island was then 1,380 feet wide on the section line.

In 1842—twenty-three years later—the channel back of Martin's Bar had closed; the channel between the Pennsylvania shore and Maiden Island had widened and deepened; Maiden Island was then 1,080 feet wide as against 1,380 in 1819, and the main ship channel to the Jersey shore had widened and decreased in area, although maintaining the same maximum channel depth. The area of cross-section was 75,560 square feet, showing a decrease of 7 per cent., and the width remained nearly the same at about 4,270 feet.

From 1842 to 1881, the channel north of Maiden Island continued to shoal up, retaining, however, the maximum depth of 1842 in a restricted channel-way near the Pennsylvania shore. Maiden Island had shifted down stream so that the section line gave 13 feet depth of water where the middle of the island was situated in 1842.

In the main ship channel the maximum depth was maintained as in 1819 and 1842, and the area of cross-section remained nearly the same as in 1842.† The noticeable change shown by this comparison is the washing away of that part of Maiden Island lying to the eastward of the section

*In section J the maximum depth in main channel was 32 feet in 1819, 35 feet in 1843, and 35 feet again in 1878. In the blind channel on the Jersey shore the maximum depth was 20 feet in 1819, 21 feet in 1843, and 17¼ feet in 1878

†Maiden Island section: the maximum depth remained the same at the different dates of comparisons—1819, 1842, and 1881—between 42 and 43 feet.

line, and the continued shift to the westward, *i. e.*, down stream. The area of cross-section was 83,990 square feet against 75,560 square feet in 1842—an increase of 11 per cent., almost entirely due to the erosion of Maiden Island and the substitution of comparatively deep water in its stead.

In view of the present occupation of Maiden Island, and of the works being erected thereon in 1881, I give below a comparison of the changes, both in surface area and in position, since 1819.

The direction of the river at this point is, in a general way, east and west, east being the direction up stream. The cross-section line as given above, ran south-southeast across the widest part of the island of 1819.

In 1819 the surface area of Maiden Island exposed at low water, was 410,491 square yards, and the area of marsh land was 281,634 square yards. The length of the island—up and down stream—was 4,000 feet, and the greatest width 1,900 feet. Taking the line of cross-section as the axis of ordinates, we find the upper end of this island 1,800 feet to the eastward of that line.

In 1842 the surface area had decreased to 159,721 square yards at the low-water stage, or 61 per cent. in twenty-three years; and the area of marsh had fallen off to 125,000 square yards, or 55 per cent. in the same period. The greatest length of the island was 2,900 feet, as against 4,000 feet in 1819, and the upper point was 850 feet to the eastward of the section line, showing a movement down stream of 950 feet in twenty-three years, or 41⅓ feet per annum.

In 1881 the position of the island shows the continued motion down stream. It had passed across the section-line so that its upper extremity was 800 feet to the westward of that line, giving a rate of motion of 1,650 feet in thirty-nine years, or 42¼ feet per annum, which does not differ materially from the previously noted rate between 1819 and 1842. The surface area also continued to decrease largely, from 159,721 square yards in 1842 to 42,052 square yards in 1881, a loss of 74 per cent. in thirty-nine years, at which rate, all things being equal, the island would disappear before 1895; but the works of revetment and protection begun in 1881, will doubtless effect the proposed reclamation and secure it from further encroachment by the stream. The area of marsh land also decreased to 28,935 square yards, *i. e.*, 76 per cent. during the same period.

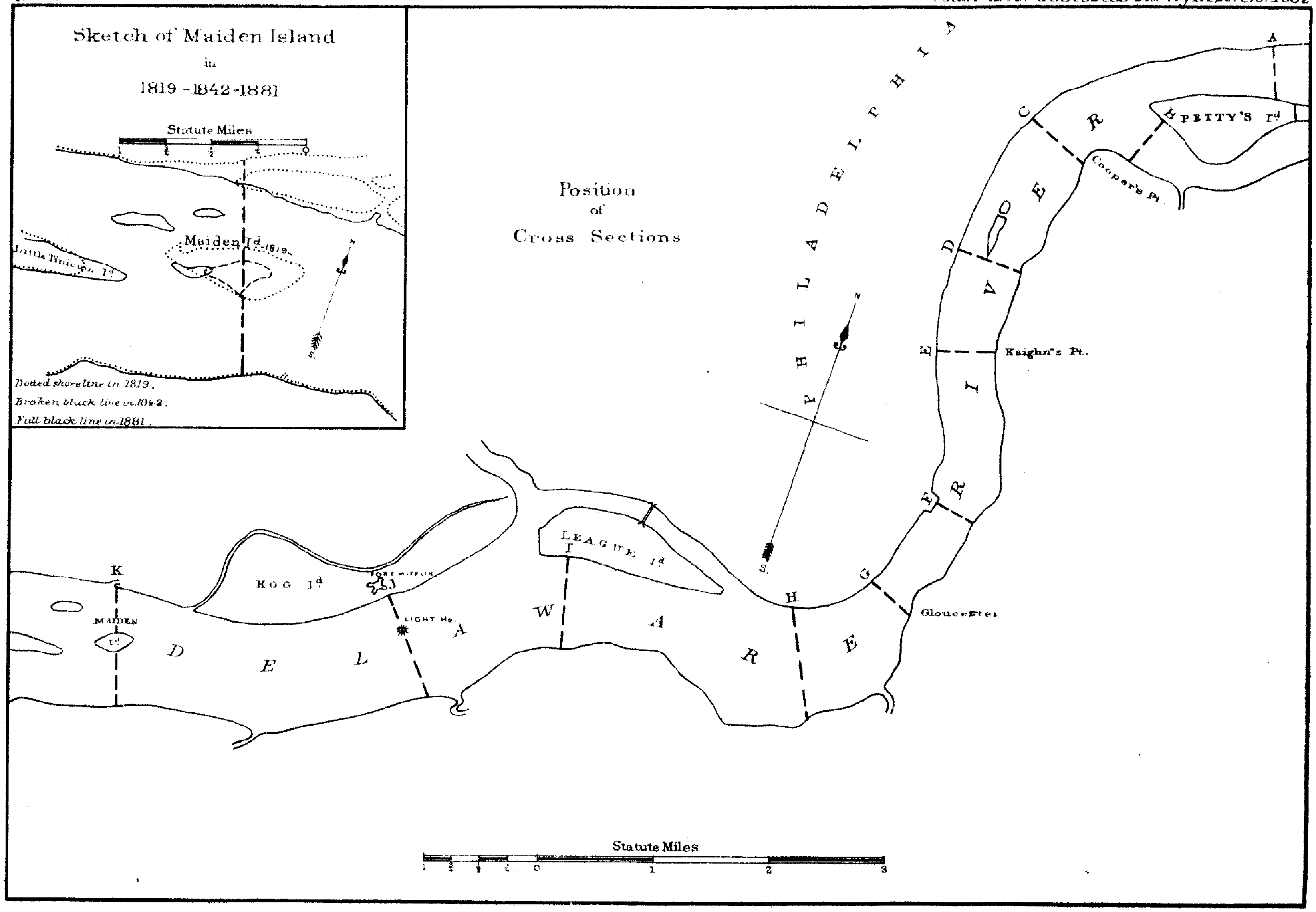
The entire loss of surface area of Maiden Island during the sixty-two years from 1819 to 1881, has been 368,439 square yards, which is 90 per cent. of its area in 1819.

In the above report I have endeavored to give simply the results of comparisons of cross-sections, as obtained from the different surveys of the Delaware River, and I have stated an opinion as to the probable causes of these changes only in cases where these seemed to me apparent.

All of which is respectfully submitted.

HENRY L. MARINDIN,
Assistant Coast and Geodetic Survey.

Prof. J. E. HILGARD,
Superintendent Coast and Geodetic Survey, Washington D. C.



Sketch of Maiden Island
in
1819 - 1842 - 1881
Statute Miles
Maiden Id
1819
Little Tinicum Id
Dotted shoreline in 1819.
Broken black line in 1842.
Full black line in 1881.
Position
of
Cross Sections
PHILADELPHIA
DELAWARE RIVER
A
B
C
D
E
F
G
H
I
J
K
PETTY'S Id
Cooper's Pt.
Kaighn's Pt.
Gloucester
LEAGUE Id
HOG Id
FORT MIFFLIN
LIGHT Ho.
MAIDEN Id
Statute Miles
0
1
2
3

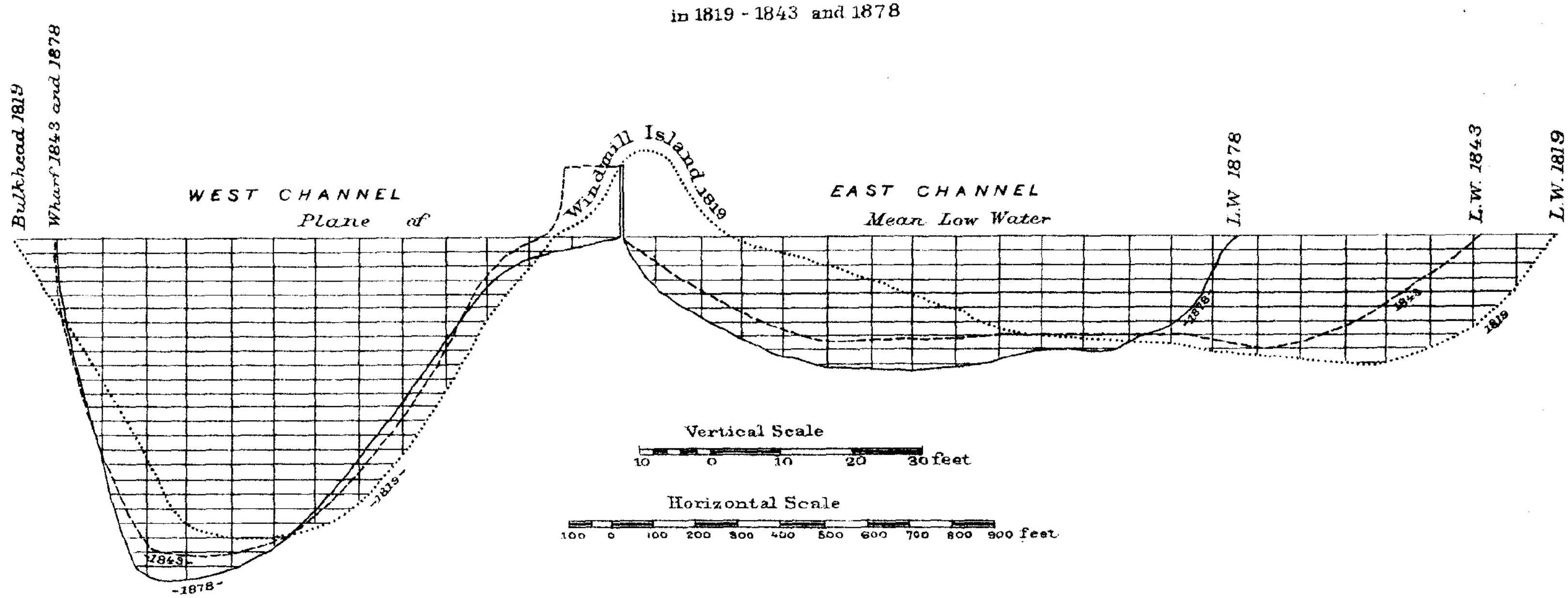
DELAWARE RIVER

Section across Jetty at south end of

WINDMILL ISLAND

From the foot of Almond street to Camden N.J.

in 1819 - 1843 and 1878

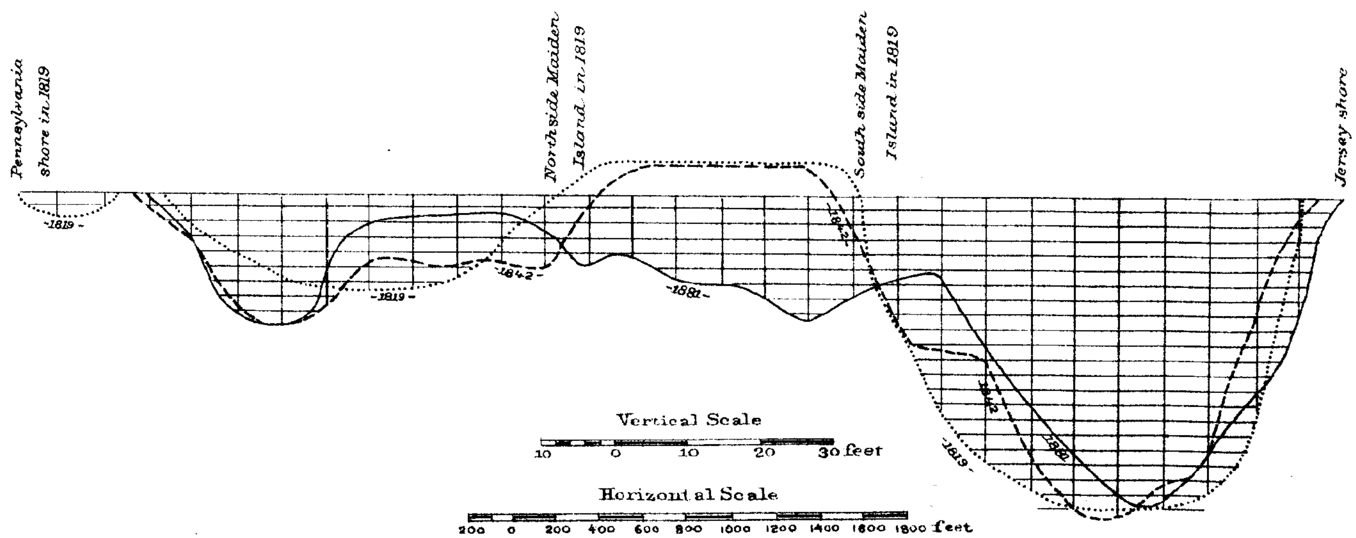


DELAWARE RIVER

Cross-Section from Pa. shore to Jersey shore

across the middle of Maiden Island

in 1819 - 1842 - and 1881



APPENDIX No. 16.

STUDY OF THE EFFECT OF RIVER BENDS IN THE LOWER MISSISSIPPI.

By HENRY MITCHELL, Assistant.

In this communication I purpose to exhibit the results of a study which I have made for the Mississippi River Commission of a portion of the river presenting the least anomalies and most permanent characteristics. This portion extends from the neighborhood of the Forts to Point Houmas; and as it was mapped by the Coast and Geodetic Survey before the Commission was instituted you have felt justified in lending assistance in a final rendering of the results. I hasten, therefore, to acknowledge the services of Messrs. J. A. Sullivan and F. D. Granger, for many years full assistants in the Coast and Geodetic Survey. These gentlemen have made the laborious compilations and computations upon which the brief tables of this review are based, and have added to well-known skill a great deal of patience in revision, &c.

I shall not go into details, because my results are very simple—as they could not fail to be—for good, honest field work bears such scrutiny even if never anticipated by the surveyors. The sources of my data will be given at the close of this paper.

The portion of the river examined covers $150\frac{3}{4}$ statute miles, measured along the channel, or 105 miles by air-line. The low-stage elements for this distance are:

Mean surface width	feet	2,333
Mean depth	do	60
Mean channel depth	do	$98\frac{1}{10}$
Mean area cross section	square feet	140,000

The greatest "*characteristic depth*" found was 225 feet, the least channel depth 54 feet.

To distinguish between positive and questionable conclusions, I shall designate the former *inductions* and the latter *inferences*.

INDUCTIONS.

1. *Bends, as increasing the depth of the river, offer, on the whole, no advantage. They cause a depression of the bed at the turns, and a corresponding elevation at the reversions.* (See Table No. 1.)

TABLE I.—A COMPARISON OF AIR-LINE AND RIVER DISTANCES WITH MEAN DEPTHS, MEAN WIDTHS, AND MEAN AREAS IN MISSISSIPPI RIVER, BEGINNING IN LAT. 39° 20′ 46″, LONG. 89° 24′ 15″, AND ENDING IN LAT. 30° 06′ 36″, LONG. 90° 54′ 47″.

[The air-lines follow the course of the river by a polygon of 6.345 miles to the side.]

Polygon sides.	River distance.	Sections.	Mean channel depth.	Mean width.	Mean depth.	Mean area.	Remarks.
	Stat. miles.		*Feet.*	*Feet.*	*Feet.*	*Feet.*	
0	0						$4\frac{1}{2}$ miles below Fort Saint Philip.
		1 to 17	121.1	2,406	74.0	174,865	
1	8.00						
		18 to 30	101.9	2,815	58.7	147,439	
2	6.75						
		31 to 45	110.0	2,220	66.9	145,267	
3	7.25						
		46 to 58	94.0	2,454	57.6	140,812	
4	6.50						
		59 to 71	96.4	2,508	57.3	140,208	
5	6.50						
		72 to 83	92.0	2,408	54.3	130,392	

TABLE 1.—*A comparison of air-line and river distances with mean depths, mean widths, and mean areas in Mississippi River, &c.*—Continued.

Polygon sides.	River distance.	Sections.	Mean channel depth.	Mean width.	Mean depth.	Mean area.	Remarks.
	Stat. miles.		*Feet.*	*Feet.*	*Feet.*	*Feet.*	
6	6.25	84 to 97	100.5	2,279	63.0	142,161	
7	6.75	98 to 111	89.8	2,343	55.2	128,418	
8	7.00	112 to 123	90.9	2,183	58.7	127,517	
9	6.25	124 to 161	97.0	2,250	64.8	143,305	
10	18.75	162 to 179	102.1	2,433	63.4	151,103	
11	9.00	180 to 195	98.6	2,350	59.3	136,128	
12	8.00	196 to 209	91.8	2,357	56.1	130,200	
13	7.00	210 to 223	84.5	2,309	50.1	115,350	Three sections rejected.
14	7.25	224 to 241	92.9	2,371	56.3	131,991	One section rejected.
15	8.75	242 to 255	98.1	2,229	62.4	138,111	
16	7.00	256 to 269	90.7	2,243	62.4	139,204	
17	7.00	270 to 288	90.3	2,442	55.2	133,692	
18	9.50	289 to 302	115.1	2,107	63.4	133,829	
19	7.25	....	....	....	....	....	Near Point Houmas.
Mean	....	....	97.8	2,337	60.0	138,421	

The length of river covered by the above table is 120½ miles by "polygon sides," 150¾ by "river distance," or 105 miles by single air-line.

SUPPLEMENTARY.

	River distance.	Mean channel depth.		River distance.	Mean channel depth.
	Miles.	*Feet.*		*Miles.*	*Feet.*
3 to 6	26.5	98.1	2 to 8	47.0	97.8
9 to 13	49.0	96.1			
14 to 17	30.0	91.6	14 to 19	46.7	95.3

REMARKS.—The data given under the head of "Mean channel depth" correspond to the half-mile chord below the angle of deflection. These depths are the means of all the soundings for each half mile following the line of greatest depression.

The design of this table is to illustrate the obliteration of bend effect in groups taken in geographical order, which include both bends and reversions.

It had been supposed by many—myself among them—that, because a deeper channel was nearly always found in the bend, navigation gained some advantage in this one respect; but it will be observed from the table that reaches in which the great bends occur have no greater average depth than others. For instance, between sections 124 and 161 of Table No. 1, the mean depth is no greater than for some nearly straight reaches, although in this case the river distance is nearly three times the length of the air-line. The thalweg (channel) depth has in this case an average differing but one foot from the grand mean. I had presumed that mean depth for bends and reversions would balance, but I had not expected compensation in thalweg depths.

2. *The mean depth of cross-section and the thalweg depth vary with inverse radius of curvature, or, practically, with angles of deflection.* (See Table No. 2.)

TABLE 2.—BEND EFFECTS IN THE MISSISSIPPI RIVER FROM $4\frac{1}{2}$ MILES BELOW FORT SAINT PHILIP TO NEAR POINT HOUMAS, $150\frac{3}{4}$ MILES.

Number of data.	Limits of included angles $\frac{1}{2}$ mile chords.	Mean deflection.	Rad. of curve $\frac{1}{2}$ mile chords.	$\frac{31522}{\text{Rad. of curv.}}$	Mean width.	Mean depth.	Mean area of section.	Number of data.	Mean channel depth.
	°	° ′	Feet.		Feet.	Feet.	Feet.		Feet.
4	120 127	54 23	2,889	10.91	2,175	90.9	196,762	4	129.3
11	134 147	40 16	3,833	8.22	2,273	73.0	162,827	10	119.4
29	$151\frac{1}{2}$ $160\frac{1}{2}$	23 33	6,468	4.87	2,290	67.6	152,509	29	116.4
71	161 170	13 27	11,272	2.80	2,262	62.2	138,504	70	102.5
175	$170\frac{1}{2}$ $179\frac{1}{2}$	4 48	31,522	1	2,375	57.6	135,493	173	92.0
8	0	0	....	....	2,362	54.8	129,237	8	82.3

The variation of thalweg-depth with curvature is limited. The gain of depth ultimates essentially at 23° or 25° deflection for half-mile chords, and within this limit is nearly proportional. Similarly, the mean-depth increases with curvature, but at first only at about half the rate found for thalweg-depth, and, within the scope of our data, there is no limit to this increase.* (See sketch No. 44.)

INFERENCES.

There appears to be a decrease (comparatively small) of river widths with curvature, and also a decrease with distance up river; both irregular. These have been ignored in previous statements, as if entirely eliminated.

There is a tendency at reversions, where one centrifugal force overlaps the other (for opposite sides of the stream), for the river to divide and erode the bed near both banks. This tendency was represented by the third term in my formula for the cross-section in the Delaware (Appendix No. 9, Annual Report Coast and Geodetic Survey, 1878).

There appear to be distinctive characteristics of reversions and straight reaches; *i. e.*, where a decided curve is followed immediately by another similar curve in reverse direction the characteristics of the straight reach do not appear.

In my notes for the Commission some practical deductions are made which may here be left to implication.

AUTHORITIES FOR DATA.

The following hydrographic sheets from our archives have been used in constructing the tables:

No. 1093. C. H. Boyd, Assistant, United States Coast and Geodetic Survey. 1871.
No. 1153. F. D. Granger, Assistant, United States Coast and Geodetic Survey. 1872.
No. 1154. C. H. Boyd, Assistant, United States Coast and Geodetic Survey. 1872.
No. 1162. C. H. Boyd, Assistant, United States Coast and Geodetic Survey. 1873.
No. 1274. C. H. Boyd, Assistant, United States Coast and Geodetic Survey. 1873–'74.
No. 1307. C. H. Boyd, Assistant, United States Coast and Geodetic Survey. 1875–'76.
No. 1343 *a*. C. H. Boyd, Assistant, United States Coast and Geodetic Survey. 1876.
No. 1343 *b*. C. H. Boyd, Assistant, United States Coast and Geodetic Survey. 1876–'77.
No. 1408. Lieut. Commander C. M. Chester, U. S. N., Assistant, United States Coast and Geodetic Survey. 1879.

* For the sharpest turns—those falling between 53° and 60°—the instances are so few that the still more rapid increase of mean depth that they indicate must be regarded as doubtful. The same remark applies to other elements in this group. It was designed to group the data for every 9° of deflection, but we had not enough to warrant this in every case.

Messrs. Sullivan and Granger, assistants in the Survey, have reported five sections rejected out of 302 covered by the tables. One of these had "*no bottom*," another was at Bonnet Carré crevasse, and three fell in whirlpools, sketched by arrows on the field sheet.

Respectfully submitted.

July, 1882.

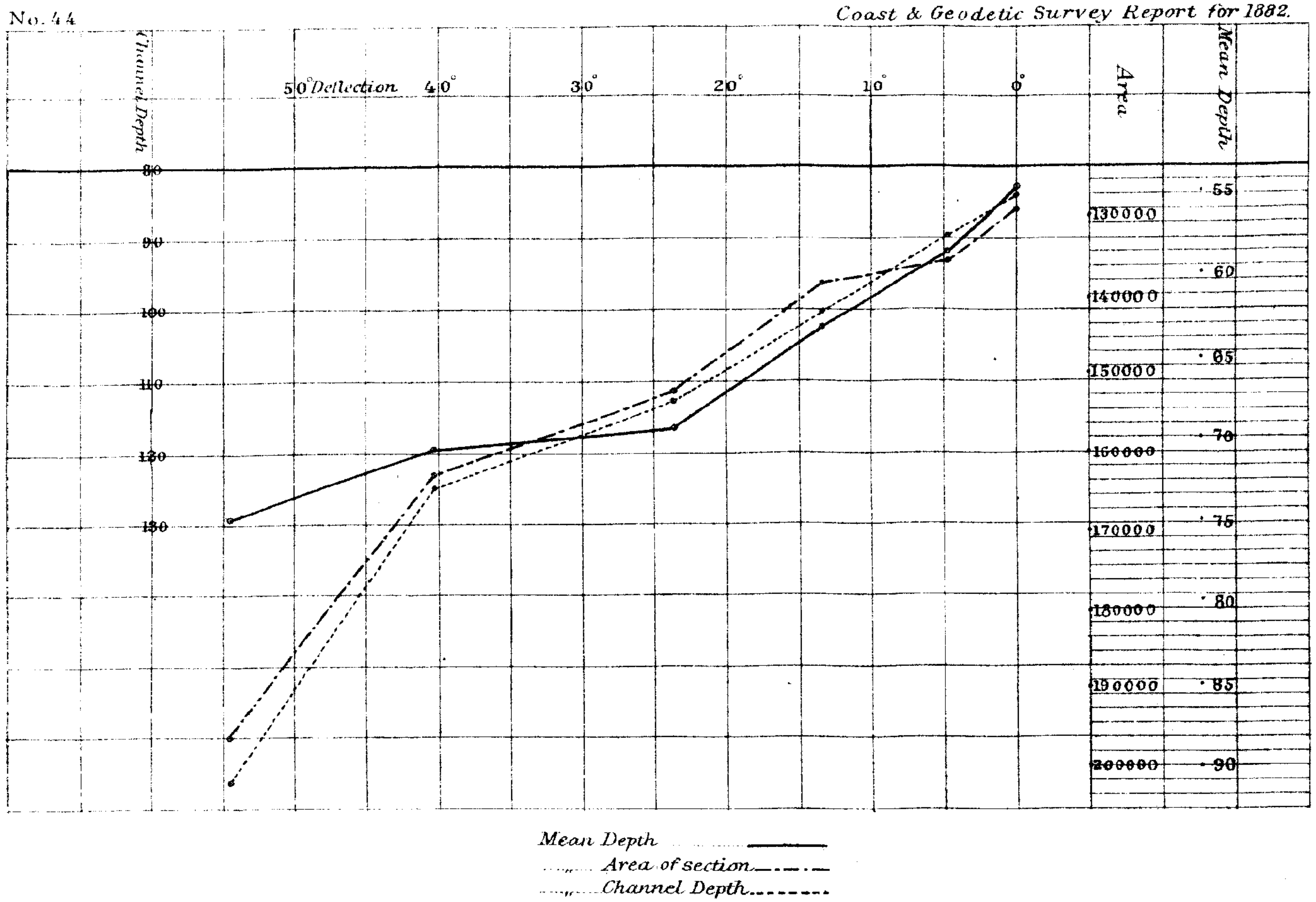
HENRY MITCHELL,
Assistant Coast and Geodetic Survey.

J. E. HILGARD, Esq.,
Superintendent Coast and Geodetic Survey.

Bend Effects
Mississippi River
To illustrate Table No. 2.

No. 44

Coast & Geodetic Survey Report for 1882.



APPENDIX No. 17.

DISCUSSION OF THE TIDES OF THE PACIFIC COAST OF THE UNITED STATES.

By WILLIAM FERREL.

COAST AND GEODETIC SURVEY OFFICE, *June* 1, 1882.

SIR: I have the honor to submit the following report on the discussion of tides of the Pacific coast: The tide-stations are Port Townsend, Wash. T., Astoria, Oreg., and San Diego, Cal. The data which have been used in the work are the hourly co-ordinates measured from the curves of self-registering tide-gauges, which have been analyzed by the harmonic method, in precisely the same manner as those of Pulpit Cove, in Penobscot Bay, a report of which is contained in Appendix No. 11 of the Coast and Geodetic Survey Report for 1878. That report gives a full account of the method of the analysis, with all the necessary formulæ and auxiliary tables used in the reductions, and was intended to be a preliminary work to all such discussions, done once for all, which need not be repeated. In the following report, therefore, this has not been done again, but very frequent references to equations, formulæ, and tables in that preliminary work have been made. All such references, therefore, in the following report, must be understood as referring to the Report on the Tides of Penobscot Bay, unless otherwise stated.

The hourly co-ordinates for three years have been used in the work for Port Townsend and San Diego, and for two years and ten months for Astoria, these being all the co-ordinates available. The whole number of co-ordinates for the three years at the three stations is about 75,000. All these, by the method, had to be arranged into groups of about 365 observations each twenty-four times, once for each of the twenty-four tide-components with reference to which they have been analyzed, and the averages thus obtained were then treated by the methods laid down in the preliminary work referred to above. The amount of work, therefore, is very great, but it makes the most possible out of the observations, and the results thus obtained are far more accurate than those of the old method of analysis of the observations of high and low waters only; and besides this, the numerous short period inequalities of quarter-diurnal, one-sixth diurnal, &c., components are obtained from the analysis, which, by the old method, are mostly, if not entirely, lost. The results in the following report can be used, either by investigators of the tidal theory or for the practical purpose of predicting the tides for any given time.

Very respectfully, yours,

WM. FERREL.

Prof. J. E. HILGARD,
Superintendent of the Coast and Geodetic Survey.

I.—TIDES OF PORT TOWNSEND.

1. Port Townsend is situated on Admiralty Inlet, Puget Sound, in Washington Territory, latitude 48° 8′ north, and longitude 122° 48′ west from Greenwich. The waters adjacent, even close to the shore, are mostly over seven fathoms in depth, and these connect with the Pacific Ocean by means of the Strait of Juan de Fuca, which has a considerable depth. The tides of Port Townsend partake of the general character of those of the northern part of the Pacific Ocean, which

mostly have a large diurnal inequality, and are analogous to those at Petropaulovsk, on the coast of Kamtchatka, long noted for the magnitude of its diurnal tide. The tides of Port Townsend are the most remarkable in this respect of any in the world where tidal observations have been made, the range of the principal diurnal component alone being nearly six feet, as is seen from the following results, while that of the mean lunar semidiurnal component, which is usually by far the greatest of all, is little more than four feet. Hence the tidal curves here are very much distorted, there being great differences between the heights of the two high or the two low waters corresponding to the upper and lower transits of the moon, and great irregularity in the intervals between high and low waters.

2. The hourly co-ordinates, measured from the curves of the self-registering tide-gauge for the years 1874–1876, inclusive, and furnished me by Mr. Avery, from the records of the Tidal Division, Coast and Geodetic Survey Office, have been used in the discussion of these tides. Treating these precisely as those of Pulpit Cove, in Penobscot Bay, as explained in sections 21–23 of the report on these tides, and using the same notations, the following results have been obtained:

M-TIDE.

	1874.	1875.	1876.	Mean.
$A_1 =$	.1884	.1504	.0652	.1347
$\epsilon_1 =$	226°	210°	161°	199°
$A_2 =$	2.1353	2.2306	2.1394	
$\epsilon_2 =$	110°.47	108°.71	107°.69	
$A_3 =$	.0205	.0149	.0221	.0192
$\epsilon_3 =$	41°	343°	298°	347°
$A_4 =$	.1278	.1128	.1254	.1220
$\epsilon_4 =$	296°.7	298°.7	294°.6	296°.7
$A_6 =$	.0322	.0270	.0275	.0289
$\epsilon_6 =$	240°	255°	236°	244°

O-TIDE.

$A_1 =$	1.6776	1.6980	1.7424
$\epsilon_1 =$	126°.29	128°.24	131°.63

P-TIDE.

$A_1 =$	.7764	.7510	.7866	.7713
$\epsilon_1 =$	145°.4	147°.4	147°.2	146°.7

N-TIDE.

$A_2 =$	.4609	.4657	.4399	.4555
$\epsilon_2 =$	81°.9	80°.8	78°.6	80°.4

λ-TIDE.

$A_2 =$	.0445	.0309	.0187	.0314
$\epsilon_2 =$	6°.3	28°.5	331°.7	2°.2

R-TIDE.

$A_2 =$	.0104	.0082	.0201°	.0129
$\epsilon_2 =$	352°	214°	241°	269°

J-TIDE.

$A_1 =$	.1615	.0496	.1487
$\epsilon_1 =$	36°	245°	167°

2 SM-TIDE.

$A_2 =$	.0113	.0172	.0180	.0155
$\epsilon_2 =$	62°.3	42°.2	41°.0	48°.5

S-TIDE.

	1874.	1875.	1876.	Mean.
$A_1 =$	.0857	.0717	.1024	.0866
$\epsilon_1 =$	113°.3	121°.0	114°.3	116°.2
$A_2 =$	.5567	.5584	.5415	.5522
$\epsilon_2 =$	130°.0	129°.4	129°.0	129°.5
$A_3 =$	.0042	.0022	.0033	
$\epsilon_3 =$	112°	352°	301°	
$A_4 =$	.0065	.0108	.0125	.0099
$\epsilon_4 =$	349°	316°	316°	327°

K-TIDE.

$A_1 =$	2.7568	2.7920	2.7936
$\epsilon_1 =$	152°.71	149°.97	147°.70
$A_2 =$	.2137	.1851	.2139
$\epsilon_2 =$	134°.6	134°.8	135°.4

L-TIDE.

$A_2 =$	.0854	.1071	.0801	.0911
$\epsilon_2 =$	347°.0	355°.4	319°.9	340°.8

μ-TIDE.

$A_2 =$	.0777	.0976	.0592	.0782
$\epsilon_2 =$	352°.0	7°.4	355°.5	358°.3

ν-TIDE.

$A_2 =$	.1556	.0891	.0289	.0912
$\epsilon_2 =$	75°.9	45°.5	136°.6	86°.0

T-TIDE.

$A_2 =$	.0706	.0500	.1084
$\epsilon_2 =$	38°	239°	175°

Q-TIDE.

$A_1 =$	.2973	.3148	.2949	.3023
$\epsilon_1 =$	119°.4	124°.0	123°.5	122°.3

MS-TIDE.

$A_4 =$	.0624	.0721	.0575	.0640
$\epsilon_4 =$	319°.3	309°.5	317°.6	315°.5

The amplitudes above are given in feet. The values of the amplitudes and epochs above are not those obtained directly from the observations, but they are these values with the small reductions applied by (20) for the values of m_s and n_s computed by the formula of section 15, and the epochs are also reduced by Table II to those which result from using the true hour of each tidal component, instead of assuming for convenience, in Table I, that the hour of midnight preceding the 1st of January (leap-year, January 2) is 0^h for each of the components. With these reductions the amplitudes and epochs should be equal for the several years, if all abnormal irregularities could be completely eliminated, except the K and O diurnal tides and the M and K semi-diurnal tides, which are affected by an inequality of long period, depending upon the position of the moon's node. Accordingly the means for these components are not given above, but are given after the following reductions by means of Tables III–VI, inclusive.

3. The amplitudes and epochs of the diurnal component of the K-tide are corrected as shown in the following table:

Years.	ω	A′	A : A′	A	Res.	ε'	$\Delta\varepsilon$	ε	Res.
	°					°	°	°	°
1874.....	32.31	2.7568	.8976—2.3 $\delta\mu$	2.4715—6.3 $\delta\mu$	+47	152.71	—3.68	149.03	+0.38
1875.....	12.97	2.7920	.8845—2.5 $\delta\mu$	2.4696—7.0 $\delta\mu$	— 2	149.97	—1.52	148.45	—0.21
1876.....	353.59	2.7936	.8825—2.5 $\delta\mu$	2.4653—7.0 $\delta\mu$	—45	147.70	+0.76	148.46	—0.19
Means..	......	......	....	2.4698—6.8 $\delta\mu$	.....	......	......	148.65	......

The values of ω in this table are taken from Table II for the middle of each year. The values of A : A′ and of $\Delta\varepsilon$ are taken from Table III, with ω as an argument. With these reductions it is seen that the amplitudes and epochs for each of the three years are very nearly the same, the maximum residual, or deviation from the mean, in the amplitudes being only about one-sixteenth of an inch, and in the epochs only 0°.38.

In the case of the O.tide the reductions are as follows:

Years.	A′	A : A′	A	Res.	ϵ'	$\Delta\epsilon$	ϵ	Res.
					°	°	°	°
1874.....	1.6776	.8389	1.4073	— 40	126.29	+5.66	131.95	+0.98
1875.....	1.6980	.8228	1.3971	—142	128.24	+2.33	130.57	—0.42
1876.....	1.7424	.8205	1.4296	+183	131.63	—1.23	130.40	—0.57
Means..	......	......	1.4113	......	......	......	130.97	......

The values of A : A′ and of $\Delta\varepsilon$ in this case are taken from Table IV, with the same values of ω for arguments as in the preceding reductions. The residuals here are a little larger than in the preceding case, but still they are very satisfactory.

In the reductions of the semi-diurnal component of the lunar or M-tide, in order to purify the results from the effect of the component of long period depending upon the position of the moon's node, we have:

Years.	A′	A : A′	A	Res.	ϵ'	$\Delta\epsilon$	ϵ	Res.
					°	°	°	°
1874.....	2.1353	1.0310	2.2015	—421	110.47	—1.17	109.30	+0.82
1875.....	2.3306	1.0361	2.3111	+675	108.71	—0.48	108.23	—0.85
1876.....	2.1394	1.0369	2.2183	—253	107.69	+0.22	107.91	—0.57
Means..	......	......	2.2436	......	......	......	108.48	......

The values of A : A′ and of $\Delta\varepsilon$ are taken from Table V with the same arguments as above. The residuals in the amplitudes in this case are larger than usual, the largest being about 0.8 of an inch. Those of the epochs are very satisfactory.

For the semi-diurnal component of the K-tide the reductions are as follows:

Years.	A′	A : A″	A	Res.	ε′	Δε	ε	Res.
					°	°	°	°
1874.....	.2137	.7998—3.9 δμ	.1706—0.8 δμ	+100	134.6	—7.0	127.6	—4.5
1875.....	.1851	.7818—4.3 δμ	.1447—0.8 δμ	—159	134.8	—2.9	131.9	—0.2
1876.....	.2133	.7789—4.4 δμ	.1666—0.8 δμ	+ 60	135.4	+1.4	136.8	+4.7
Means	......	......	.1606—0.8 δμ	......	......	......	132.1	......

Table VI is used in the reductions in this case, with the same values of ω for an argument as in the preceding reductions. The residuals are entirely satisfactory, those of the epochs being large in comparison with those of the preceding reductions, on account of the smallness of the amplitude of this component, which is only about two inches; for the epochs become very uncertain where the tide-component is so small.

The unreduced amplitudes and epochs must be used in practice for computing tides, in order to take in the effect of the long period component, depending upon the position of the moon's node, but the reduced values, which are those of the mean tide for a long series of years, are necessary in comparisons of the results with theory, and in testing the accuracy of the results deduced from the analysis of the observations. For practical purposes the amplitudes and epochs for any given year of the nodal period can be obtained from the mean values by reductions by means of Tables III–VI, inclusive, which are just the reverse of those above.

4. In the M-tide it is seen that there is a considerable diurnal component brought out by the analysis, with amplitudes and epochs A_1 and E_1, varying from year to year. This arises from the two components in Schedule I, designated by m and n, and of which the values of P are respectively .052 and .011. The periods, it is seen, differ very little, the one being a little greater and the other a little less than a lunar day. The resultant of these two components, with periods so nearly equal, gives rise to inequality brought out in the analysis, the slowly shifting relations between the two components causing the gradual change in the values of the amplitudes and epochs. The combination of these two components, as shown in section 28, gives rise to a resultant component of the form

$$A'' \cos (i_1 t - \varepsilon'')$$

in which

$$A'' = A \sqrt{1.045 + .423 \cos 2\hat{\omega}}$$

$$\varepsilon'' = \varepsilon + \tfrac{1}{2}\pi - \hat{\omega} + \delta\varepsilon$$

$$\tan \delta\varepsilon = \frac{11 \sin 2\hat{\omega}}{52 + 11 \cos 2\hat{\omega}} = \frac{\sin 2\hat{\omega}}{4.727 + \cos 2\hat{\omega}}$$

The value of A is deduced from the following relation, neglecting the correction for the moon's mass:

$$2.4698 = .5306\,(1 + .230\ \mathrm{E})\ \mathrm{A}_0$$

$$\mathrm{A} = .0520\,(1 + .002\ \mathrm{E})\ \mathrm{A}_0$$

It will be shown that the value of E for these tides is .500. Hence we have these two equations to determine the values of A_0 and A, from which we get A=.2170.

The value of ε is determined from the relation—

$$148.65 = \mathrm{L}_0 + 13.18\ \mathrm{G}$$

$$\varepsilon = \mathrm{L}_0$$

The value of G will be shown to be for these tides equal .670. With this value these two equations give $\varepsilon = 139^\circ.82$.

From Table II we get for the value of $\tilde{\omega}$, for the middle of each year, the values given below. With these values of $\tilde{\omega}$, and with the values of A and ε just found, the formula above gives the following results:

Years.	$\tilde{\omega}$	A″	A_1 (obs'd).	$\delta\varepsilon$.	ε''	ε_1 (obs'd).
	°			°		°
1874	16.8	.2564	.1884	+ 5.7	218.7	226
1875	57.5	.2018	.1504	+12.0	184.3	210
1876	98.3	.1714	.0652	− 1.7	129.8	161

The agreement between the theoretical and observed values here is not very close, but it is seen that both decrease from year to year somewhat after the same law, and the agreement is sufficient to show that this inequality deduced from the observations arises in the manner just explained, for it must be borne in mind that the relations above, from which the preceding theoretical values are deduced, are those of deep-water tides, in which the perturbing effects of the shallow-water components do not enter.

It is seen above that the value of A, and consequently of A″, depends upon the amplitude of the principal diurnal component, 2.4698, which is unusually large in these tides. A very small inequality of the same kind was obtained in the analysis of the observations of Penobscot Bay, where the diurnal tide is very small. It is interesting to observe that this inequality at Port Townsend is larger than in Penobscot Bay, about in the ratio of the principal diurnal tide; which is further evidence that this inequality arises in the way explained theoretically above.

5. The ter-diurnal component of the M-tide, it is seen, is very small, and not clearly brought out by the analysis, as is seen from the scattering values of the epochs ε_3, and it is probable there is no real sensible tide of this sort, and that the very small values obtained are due to uneliminated abnormal disturbances. The term in the tidal forces giving rise to such a tide, is so extremely small that a sensible tide could scarcely be expected.

The quarter-diurnal component of the M-tide, though small, is very clearly brought out in the analysis, as is seen from the regularity, from year to year, of both the amplitudes A_4 and the epochs ε_4. This is purely a shallow-water tide, being the tide designated by $M_2\ M_2$ in Schedule IV. A small part of it may arise from the component $M_2\ M_6$ of Schedule VI, since the latter has the same period.

The one-sixth diurnal shallow-water component, of the M-tide, though very small, is clearly brought out in the analysis, as is shown by the nearly equal values of the amplitudes A_6 and the epochs ε_6 for the several years. This is the shallow-water component, designated by $M_2\ (M_2\ M_2)$ in Schedule VI.

In the S-tide there is also a small diurnal component, with amplitudes and epochs for the several years nearly the same. There should be a theoretical component of this sort, just as in the case of the moon, arising from the solar elliptic and declinational components; but, as the solar force is less than half the lunar, and the ellipticity of the solar orbit only about one-third of that of the lunar, this inequality would have to be very small in comparison with the lunar one. This inequality, as brought out in the analysis, seems to be too large for this theoretical tide, and it must be due, in part at least, to some other cause. The amplitude of the whole tide is only about an inch.

6. The amplitudes and epochs of the L-tide, as usual, are irregular, since they are affected by a shallow-water component of very nearly the same period, the effect of which is not eliminated in the analysis. This is the fourth component of the second group in Schedule V, not written out, but the designation of it would be $M_2\ (S_2\ N_2)$, and the value of u would be $2i_2+2i_5-2i_1=29.455626$, which is very nearly the value of $2i_4$ in Schedule I, belonging to the semidiurnal component of the L-tide. Hence this component is always irregular, as brought out by the analysis, where there are sensible shallow-water tides.

The amplitudes and epochs of the N-tide are very regular, which shows that it is but little affected by any shallow-water components having nearly the same period.

The μ-tide is affected by a shallow-water component having precisely the same period. This component is designated by $S_2\ (M_2,\ M_2)$ in Schedule V. Having exactly the same period, it should not derange the values of the amplitudes and epochs from year to year, but it destroys the theoretical relation between the forces and the corresponding components deduced from the theory of deep-water tides. The amplitudes and epochs in this case, as brought out in the analysis, are as regular as is to be expected.

The R- and T-tides at Port Townsend should be very small theoretically, especially the former, and from the irregularities of both the amplitudes and epochs obtained from the analysis, the results are probably the uneliminated effects of shallow-water components and abnormal irregularities.

The diurnal J component is too small to be brought out clearly in the analysis, and the irregular results obtained are, no doubt, due to uneliminated disturbances. This tide should be only about one-fifth of the Q-tide.

The regularity of the amplitudes and epochs of the diurnal Q-tide, none of them differing much from the mean of the three years, indicates that this is the true theoretical tide with all the other inequalities and the abnormal disturbances almost completely eliminated.

7. The quarter-diurnal component of the S-tide, as shown by the nearly equal values of the epochs ε_4, in this very small component, is evidently a real component. This is the component designated in Schedule IV by $S_2 S_2$. The relation between this and the quarter-diurnal M-tide, designated by $M_2 S_2$, is given by the values of R in the second column of the Schedule, if we suppose the quarter-diurnal component of the lower order in Schedule VI, having the same period, to be insensible. This relation makes the amplitudes of the quarter-diurnal components proportional to the second powers of the amplitudes of the semi-diurnal components, and hence—

$$\frac{A'_2}{A'_1}=\frac{A_2^2}{A_1^2}$$

in which the amplitudes in the first member, distinguished by an accent, are those of the lunar and solar quarter-diurnal components, and those in the second member belong to the lunar and solar semi-diurnal components. Now, the values of A_1, A_2, and A'_1, as obtained from the analysis of the observations, are, respectively, 2.1684, 0.5522, and 0.1220. Hence we have—

$$A'_2=\frac{0.5522^2}{2.1684^2}\times.1220=.0080$$

This value, given by theory, differs only one forty-fourth of an inch from the value .0099 deduced from the analysis of the observations. In the same manner all the other amplitudes of the quarter-diurnal components of Schedule IV can be theoretically deduced from those of the semi-diurnal components. In the Port Townsend tides, however, these are all very small and of no importance.

With regard to the theoretical relation of the epochs, if we put the expression of these shallow-water quarter-diurnal components (*e. g.*, 7, p. 8) into the form of each one of the components of the second member of (2), which is the form under which the analysis of the observations has been made, we shall have—

$$h=A\cos(u_n t-\varepsilon_n)$$

in which, after reduction by Table II,

$$\varepsilon=q-E$$

Substituting the values of q in Schedule IV, and denoting the epochs of the quarter-diurnal components by an accent, we get

$$\varepsilon'_1=2\varepsilon_1-E \text{ for the lunar tide,}$$

and

$$\varepsilon'_2=2\varepsilon_2-E \text{ for the solar tide.}$$

Now the values of ε'_1, ε_1, and ε_2, as obtained from the analysis of the observations, are, respectively, 296°.7, 108°.3, and 129°.5. Hence we get from the preceding expressions—

$$\varepsilon'_2=\varepsilon'_1+2\,\varepsilon_2-2\,\varepsilon_1=296^\circ.7+259.^\circ0-216^\circ.6=339.^\circ1$$

This value of ε'_2, deduced from the theoretical relations of the epochs, differs only 12° from the value 327°, obtained from the analysis, which is a very satisfactory agreement of the values, considering the smallness of the component, the amplitude of which is only about one-eighth of an inch.

The quarter-diurnal, shallow water, component of the MS-tide, designated by M_2 S_2 in Schedule IV, is a real component, as indicated by the regularity from year to year of the amplitudes and epochs, A_4 and ε_4. These can be deduced theoretically in the same manner as those of the S_2 S_2 component in the preceding case. It is only necessary, as is seen by comparing the values of R and q in Schedule IV in the two cases, to use $2A_1$ A_2 instead of A_2^2, and $\varepsilon_1+\varepsilon_2$ instead of $2\varepsilon_2$ in the preceding equations. Hence instead of the preceding relation of the amplitudes we get

$$\frac{A'}{A'_1}=\frac{2A_2}{A_1}$$

or

$$A'=\frac{2A_2}{A_1}\times A'_1=\frac{2\times 0.5522}{2.1684}\times .1220=.0611.$$

This theoretical value is almost precisely the same as the value .0640 obtained from the analysis of the observations, the difference being only about one-thirtieth of an inch. In like manner, by putting $\varepsilon_1+\varepsilon_2$ for $2\varepsilon_2$ in the expression above, we get

$$\varepsilon'=\varepsilon'_1+\varepsilon_2-\varepsilon_1=296°.7+129°.5-108°.3=317°.9.$$

This theoretical value of ε' differs only 2°.4 from that of 315°.5 given by the analysis of the observations, although the amplitude of the component is only about three-fourths of an inch.

The shallow-water semi-diurnal component of the 2 SM-tide, designated by M_2 (S_2 S_2) in Schedule V, although very small, is clearly brought out by the analysis, as indicated by the regularity from year to year of the amplitudes and epochs. We have no relations for determining the amplitude and epoch of this component theoretically.

8. The observations were analyzed for each of the four principal long period components, but no sensible inequality was obtained, as shown by the scattering values of the amplitudes and epochs for the several years, except that corresponding to the solar elliptic declination component. This, however, arises from meteorological causes, the part depending upon the tidal forces, as in the other cases, being entirely insensible. The theoretical expression of these long-period inequalities makes the amplitudes very small for any part of the globe, and entirely vanish in the case of an earth entirely covered by water, at the parallel of 35° 16'. Hence we could scarcely expect a sensible effect, even at the latitude of Port Townsend, and none was found in the tides of Penobscot Bay.

For the solar elliptic declination inequality, due to meteorological causes, there has been obtained

	1875.	1876.
$A_1=$	.229	.212
$\varepsilon_1=$	331°	15°
$A_2=$	.158	.079
$\varepsilon_2=$	296°	95°

The fluctuations in the zero of the tide-gauge for the year 1874 rendered it impossible to get any satisfactory results for that year, and the results for the other two years are perhaps slightly affected from this cause. The combined annual and semi-annual components give an inequality with a maximum of nearly 4 inches above mean level, occurring in December.

The analysis gave no sensible value for the shallow-water long period component M_2S_2 of Schedule IV.

The heights of mean level above the zero of the tide-gauge as obtained from the analysis, are

	1874.	1875.	1876.
$A_0=$	10.559 ft.	10.966	10.976

It is seen there must have been a considerable change in the position of the zero-plane during the year 1874.

II.—TIDES OF ASTORIA.

9. Astoria is situated on the Columbia River, Oregon, about ten miles from its mouth, latitude 46° 11′ north, and longitude 123° 50′ west from Greenwich. The river here is wide, but obstructed by bars and sand-banks, and has two principal channels, the southern one of which is the wider and deeper one, having a depth of about 30 feet at the entrance to the river, and extending up to Astoria, with an average depth of 40 to 50 feet. The hourly co-ordinates of about two years and ten months have been used in the analysis of these tides, commencing with January, 1874, and extending to the last of October, 1876. The type of the tide differs considerably from that of Port Townsend, the diurnal tide here being less than half as large, while the semi-diurnal is about one-third greater. Still, it partakes of the general character of the Pacific tides, and is very different from those of the Atlantic, in which the diurnal tide is very small in comparison with the semi-diurnal.

10. The analysis of the observed co-ordinates, and all the reductions of the results, having been made in precisely the same manner as in the case of Port Townsend, the following results have been obtained:

M-TIDE.

	1874.	1875.	1876.	Mean.
$A_1=$	.1246	.1180		
$\epsilon_1=$	233°.5	185°.0		
$A_2=$	2.9626	2.9424	2.9053	2.9368
$\epsilon_2=$	11°.96	11°.53	11°.47	11°.65
$A_3=$	.0214	.0131	.0285	.0210
$\epsilon_3=$	106°.7	63°.0	33°.6	67°.8
$A_4=$	.0925	.0952	.1162	.1013
$\epsilon_4=$	320°.5	329°.0	328°.6	326°.0
$A_6=$	.0332	.0264	.0331	.0309
$\epsilon_6=$	121°	115°	111°	116°

O-TIDE.

	1874.	1875.	1876.	Mean.
$A_1=$	.7728	.7516		.7622
$\epsilon_1=$	118°.5	118°.1		118°.3

P-TIDE.

	1874.	1875.	1876.	Mean.
$A_1=$	.3736	.3465		.3600
$\epsilon_1=$	96°.43	95°.91		96°.17

N-TIDE.

	1874.	1875.	1876.	Mean.
$A_2=$	.5744	.5559	.5427	.5585
$\epsilon_2=$	351°.6	350°.8	345°.2	349°.2

λ-TIDE.

	1874.	1875.	1876.	Mean.
$A_2=$	.0730	.0318	.0346	.0465
$\epsilon_2=$	192°	200°	150°	181°

R-TIDE.

	1874.	1875.	1876.	Mean.
$A_2=$	.0157	.0017	.1255	
$\epsilon_2=$	259°	320°	148°	

S-TIDE.

	1874.	1875.	1876.	Mean.
$A_1=$	.0511	.0532		.0522
$\epsilon_1=$	111°.9	117°.4		114°.6
$A_2=$	.7782	.7735	.8114	.7877
$\epsilon_2=$	39°.2	38°.1	41°.0	39°.5
$A_3=$	.0040	.0083	.0120	.0081
$\epsilon_3=$	269°	310°	272°	284°
$A_4=$	.0120	.0089	.0065	.0091
$\epsilon_4=$	344°	341°	348°	344°

K-TIDE.

	1874.	1875.	1876.	Mean.
$A_1=$	$1.2896-3.0\delta\mu$	$1.2884-3.2\delta\mu$		$1.2896-3.1\delta\mu$
$\epsilon_1=$	129°.00	129°.43		129°.22
$A_2=$	$.2326-0.9\delta\mu$	$.2148-0.9\delta\mu$		$.2237-0.9\delta\mu$
$\epsilon_2=$	24°.1	27°.0		25°.5

L-TIDE.

	1874.	1875.	1876.	Mean.
$A_2=$	.1173	.1190	.1089	.1124
$\epsilon_2=$	197°.5	215°.4	198°.1	203°.9

μ-TIDE.

	1874.	1875.	1876.	Mean.
$A_2=$	.0163	.0298	.0400	.0287
$\epsilon_2=$	130°	142°	108°	126°.7

ν-TIDE.

	1874.	1875.	1876.	Mean.
$A_2=$	.2024	.1270	.1288	.1527
$\epsilon_2=$	342°.3	11°.6	53°.4	15°.8

T-TIDE.

	1874.	1875.	1876.	Mean.
$A_2=$	.0832	.0670	.0581	
$\epsilon_2=$	307°	137°	169°	

J-TIDE.

	1874.	1875.	1876.	Mean.
$A_1=$	.0673	.0086		
$\epsilon_1=$	172°	142°		

Q-TIDE.

	1874.	1875.	1876.	Mean.
$A_1=$	.1754	.1557		.1656
$\epsilon_1=$	109°	120°		114°.5

MS-TIDE

$A_4=$	.0553	.0491	.0526	.0523
$\epsilon_4=$	341°	344°	4°	350°

2 SM-TIDE.

$A_2=$	.0175	.0208	.0304	.0229
$\epsilon_2=$	220°	259°	246°	242°

The year 1876 not being complete, it was inconvenient to obtain correct results for some of the components for that year, and so they have been omitted. It was thought unnecessary to give in detail here the whole process of the reductions which have been given in section 3 in the case of the Port Townsend tides, but the amplitudes and epochs, as corrected in that way, are given above. Where the amplitudes of the components are so small and the values of the epochs so scattering in a few cases as to indicate that the results obtained are not those of a real tide, the means, as in the case of the Port Townsend tides, are not given.

11. It is seen that in both the M- and the S-tide there is considerable diurnal component, as in the tides at Port Townsend, and explainable in the same way, and that these tides are less, somewhat in proportion to the diurnal tides generally at the two ports, as they should be according to theory.

The amplitudes and epochs of the semi-diurnal component of the M-tide, when corrected for the position of the moon's node, are very satisfactory, since none of them differ much from the mean of the three years. The ter-diurnal component of this tide, as usual, is very small, and the epochs somewhat irregular, but they indicate a real component. The quarter-diurnal, shallow-water component of this tide is somewhat less than at Port Townsend, although the semi-diurnal component is considerably greater. The sixth-diurnal component, also a shallow-water component, is only about one-third of that of the quarter-diurnal, but the regularity of the amplitudes and epochs, as brought out in the analysis, indicates that it is a true component.

The regularity in the amplitudes and epochs of the S-tide, from year to year, is very satisfactory, and, although the ter-diurnal and quarter-diurnal components of this tide are very small, the regularity is such as to indicate that they are real components. The theoretical value of A_4 for this tide is given by the expression of A'_2, in section 7 in the case of the Port Townsend tides, by using the quantities in that expression in this case deduced from the Astoria tides. Hence we get

$$A'_2=\frac{0.7877^2}{2.9368}\times .1013=.0070$$

This differs but little from the value .0091 obtained from the analysis, for the whole amplitude is only one-ninth of an inch. The theoretical value of the epoch is given by the expression ϵ'_2 of that section, which, with the values of the epochs for the Astoria tides, gives

$$\epsilon'_2=326°+79°-23°=22°$$

The value given by the analysis is $-16°$. The difference is not large, considering the smallness of the component and the uncertainty in the epochs of such components.

The amplitudes of the L-tide, which, for reasons given in section 6 preceding, are usually somewhat irregular, happen to be in this quite regular, but the usual irregularity is seen in the values of the epochs.

The μ-tide at Astoria is much smaller than at Port Townsend, though the semi-diurnal components of the former are in general greater than those of the latter place. But this component is affected by a shallow-water component of the same period, independent directly of the tidal forces, and this seems to affect the part depending directly upon the forces differently at the two places.

The shallow-water MS-tide, as brought out by the analysis, seems to be a true tide, the amplitudes and epochs being quite regular for so small a component. The theoretical value of the amplitude of this component is given by the expression in section 7 preceding, which, with the values of the quantities in the expression belonging to the Astoria tides, gives for the amplitude

$$A' = \frac{2 \times .7877}{2.9368} \times .1013 = .0536$$

This is almost precisely the same as the value .0523 given by the analysis of the observations.

For the theoretical value of the epoch we likewise get from the expression of ε' in the same section

$$\varepsilon' = 326^\circ.0 + 39^\circ.5 - 11^\circ.6 = 353^\circ.9$$

which is a satisfactory agreement with the value 350° obtained by the analysis, since in so small components there is great uncertainty in the values of the epochs.

12. The observations were analyzed with reference to the long-period tides, but no sensible inequalities were obtained, as was to be expected, except in the case of the solar-elliptic inequality, produced by meteorological causes. For Astoria being still nearer the latitude where these inequalities should vanish than Port Townsend, where the inequalities depending upon the tidal forces were insensible, they should likewise be so at Astoria. The inequalities depending upon meteorological causes were found to be

	1874.	1875.
$A_1 =$	.289	.199
$\varepsilon_1 =$	43°	334°
$A_2 =$	.163	.330
$\varepsilon_2 =$	332°	282°

The results for the two years differ considerably, owing no doubt to irregularities in the zero-plane of the tide-gauge, but they correspond pretty well with the results at Port Townsend, giving an annual inequality with a maximum above the mean toward the close of the year of about 4 inches. The observations for 1876 not being complete, no attempt was made to obtain this inequality for this year.

The mean height of sea-level above the zero-plane of the tide-gauge for the several years, as obtained from the analysis, is as follows:

	1874.	1875.	1876.
$A_0 =$	9.364 feet.	9.306	9.561

It is seen that the result for the last year is too large, indicating a lowering of the zero of the tide-gauge for that year.

III.—TIDES OF SAN DIEGO.

13. San Diego is situated on San Diego Bay, California, latitude 32° 43′ north and longitude 117° 10′ west from Greenwich. The connection with the Pacific is by means of a channel, about five miles in length, and about 50 feet in depth on the average, and having its entrance at Point Loma. The hourly co-ordinates, measured from the curves of a self-registering tide-gauge for three years, commencing with January 1, 1869, have been analyzed in order to obtain the constants of the principal components of the tide for this station. The following results have been obtained:

M-TIDE.

	1869.	1870.	1871.	Mean.
$A_1 =$	.0850	.0601	.0446	.0632
$\varepsilon_1 =$	347°	333°	20°	353°
$A_2 =$	1.7097	1.7030	1.6972	1.7030
$\varepsilon_2 =$	278°.92	279°.03	280°.11	279°.35
$A_3 =$	.0077	.0118	.0050	.0082
$\varepsilon_3 =$	32°	67°	48°	49°
$A_4 =$	.0254	.0264	.0303	.0274
$\varepsilon_4 =$	200°	193°	194°	195°.7
$A_6 =$	.0104	.0106	.0087	.0099
$\varepsilon_6 =$	150°	118°	110°	126°

S-TIDE.

	1869.	1870.	1871.	Mean.
$A_1 =$	.0236	.0238	.0232	.0235
$\varepsilon_1 =$	54°	51°	12°	39°
$A_2 =$	.7006	.6967	.7158	.7044
$\varepsilon_2 =$	274°.2	274°.4	275°.2	274°.6
$A_3 =$	.0060	.0061	.0058	.0060
$\varepsilon_3 =$	167°	153°	168°	162°.7
$A_4 =$	.0064	.0048	.0056	.0056
$\varepsilon_4 =$	221°	196°	204°	207°

O-Tide.				K-Tide.			
1869.	1870.	1871.	Mean.	1869.	1870.	1871.	Mean.
				$A_1=1.0096+2.1\delta\mu$	$1.0099+0.7\delta\mu$	$1.0095-0.5\delta\mu$	$1.0097+0.8\delta\mu$
				$\epsilon_1=96°.43$	95°.91	96°.27	96°.20
$A_1=.6974$	.6982	.7139	.7032	$A_2=.2073+0.4\delta\mu$	$.2015+0.4\delta\mu$	$.1943+0.5\delta\mu$	$.2010+0.5\delta\mu$
$\epsilon_1=70°.90$	71°.42	71°.88	71°.40	$\epsilon_2=267°.5$	265°.0	265°.7	266°.1
P-Tide.				L-Tide.			
$A_1=.3582$	.3488	.3394	.3488	$A_2=.0652$	.0277	.0318	.0415
$\epsilon_1=92°.83$	91°.65	94°.51	93°.00	$\epsilon_2=62°$	29°	117°	69°
N-Tide.				μ-Tide.			
$A_2=.4232$	.4122	.4014	.4123	$A_2=.0243$	.0370	.0167	.0260
$\epsilon_2=261°.9$	263°.1	264°.4	263°1	$\epsilon_2=256°$	244°	258°	253°

14. The diurnal components of the M- and S-tides appear above as in the cases of the Port Townsend and Astoria tides, and in about the proportion of the other diurnal components. The amplitudes and epochs of the diurnal component of the M-tide are very regular, differing but little from the mean of the three years. It is seen that the amplitude is much smaller than at either Port Townsend or Astoria. The ter-diurnal component is extremely small but clearly brought out by the analysis, as shown by the epochs. The quarter-diurnal shallow-water component of this tide is also small, being little more than one-fifth of that of Port Townsend and Astoria. The one-sixth diurnal shallow-water component is very small, but clearly brought out by the analysis.

The amplitudes and epochs of the semi-diurnal component of the S-tide are very regular and satisfactory. The shallow-water ter-diurnal and quarter-diurnal component, both very small, are brought out with great regularity. The value of the amplitude of the quarter-diurnal component, given by the theoretical relation, as in the tides of Port Townsend and Astoria, is

$$A'=\frac{.7044^2}{1.7032^2}\times .0274=.0048$$

which differs but little from .0056 obtained by the analysis. The theoretical value of the epoch is

$$\epsilon'=195°.7+189°.2-198°.7=186°$$

This is as near an agreement with the value 207° from the analysis as could be expected in so small a component.

The amplitudes and epochs of the K- O- and P-tides are very regular and satisfactory. Those of the L-tide are somewhat irregular, as usual, for reasons already given in section 6 preceding, but those of the N-tide are very regular and satisfactory. The μ tide, partly shallow-water, is very small in these tides.

The other components have not been obtained from the analysis, being very small and of little importance in these tides, in which all the components are small. They can be obtained from theory, if needed, with as much accuracy as they could be from the observations.

The 2SM-tide, not obtained by analysis, is given by the theoretical relations in section 7 preceding. For the amplitude we have

$$A'=\frac{2\times .7044}{1.703}\times .0274=.0226$$

and for the epoch

$$\epsilon'=195°.7+274°.6-279°.3=191°$$

It is seen that the amplitude of this component is only about $\frac{1}{4}$ of an inch.

15. The following were obtained for the annual and semi-annual components depending upon meteorological causes:

	1869.	1870.	1871.	Mean.
$A_1 =$	.183	.279	.221	.228
$\varepsilon_1 =$	289°	260°	253°	267°
$A_2 =$	.114	.125	.104	.114
$\varepsilon_2 =$	110°	52°	61°	74°

The average height of mean level above the zero-plane of the tide-gauge is,

	1869.	1870.	1871.	Mean.
$A_0 =$	5.978 ft.	5.847	5.814	5.888

The preceding amplitudes and epochs, after the reductions stated in section 3 preceding, for any special year, can be used for computing the tides, as in the cases of Port Townsend and Astoria.

IV.—DETERMINATION OF THE GENERAL CONSTANTS.

16. *Diurnal components.*—The amplitudes of the five principal diurnal components, for each of the three stations, should satisfy the following equations in the case of deep-water tides, with the constants A_0, E, and $\delta\mu$ determined from any three of them, or if the mass of the moon, $\frac{1}{80}$ of that of the earth, is assumed to be correct, they should satisfy them with the constants A_0 and E determined from any two of them. The last members of these equations are taken from section 31 of Report on the Tides of Penobscot Bay, and with the results obtained from the preceding analysis for these five components, we get the following three sets of equations:

	Port Townsend.	Astoria.	San Diego.	
K-tide,	$2.4698 - 6.8\,\delta\mu$	$1.2890 - 3.1\delta\mu$	$1.0097 + 0.8\delta\mu$	$= (.5306 - 13.1\delta\mu)\ (1 + .230\,E)\ A_0$
O-tide,	1.4113	0.7622	0.7030	$= .3813\ (1 - .230\ E)\ A_0$
P-tide,	0.7713	0.3600	0.3488	$= (.1730 - 13.6\delta\mu)\ (1 + 196\ E)\ A_0$
J-tide,	....	....		$= .011\ (1 + .458\,E)\ A_0$
Q-tide,	0.3023	0.1656		$= .052\ (1 + 458\,E)\ A_0$

The amplitudes of the J-tide are so small that they were not brought out clearly in the analysis, and so they are omitted above.

The solution of the first three of these equations for Port Townsend gives $A_0 = 4.190$, $E = .518$ and $\delta\mu = .00046$. With this value of $\delta\mu$ we get—

$$\mu = .0125 + .00046 = .01296 = \frac{1}{77.2}$$

With these values of A_0 and E, in the last two equations, we get .1676 instead of .3023 for the amplitude of the Q-tide. This indicates that the shallow-water component combined with this tide produces a considerable effect upon its value. The value of the amplitude of the J-tide, thus obtained, is .0573. But this component is also affected by a shallow-water component of the same period.

The solution of the same equations above, with regard to Astoria, gives $A_0 = 2.285$, $E = .529$, and $\delta\mu = .002174$. This value of $\delta\mu$ gives $\mu = .014674 = \frac{1}{68.9}$. With these values of A_0 and E, we get for the amplitudes of the J- and Q-components, .0310 and .0901. The amplitude of the former was not obtained from the analysis, but that of the latter, 0.1656, is larger than the preceding theoretical value.

The solution of the same equations gives for San Diego $A_0 = 1.846$, $E = .003$, and $\delta\mu = -.001142$. With this value of $\delta\mu$ we get $\mu = .01166 = \frac{1}{85.8}$. With the values of A_0 and E, the last two of the equations give for the amplitude of the J- and Q-components, respectively, .020 and .096. In these tides the effect of E is sensibly nothing, so that the relations between the co-efficients in the tidal forces are the same as in the amplitudes of the corresponding diurnal components.

The different values obtained for the moon's mass at the several stations are caused by the effect of the shallow-water components, combined with those depending directly on the forces, and no such determination can be relied upon except from the relations of deep-water tides, in which the shallow-components disappear.

17. The following are the equations for determining the values of L and G for each of the tide stations:

	Port Townsend.	Astoria.	San Diego.
	°	°	° °
K-tide,	148.6	129.2	96.2=L+13.18G
O-tide,	131.0	118.3	71.4=L−13.18G
P-tide,	146.7	125.4	93.0=L+11.22G
J-tide,	[157.3]	[134.6]	[108.5]=L+26.25G
Q-tide,	122.3	114.5	[59.1]=L−26.25G

The first members of these equations for the several stations are the epochs obtained from the analysis of the observations, except those in brackets, which were not obtained from the analysis, but theoretically. The last members are taken from section 32 of the Report on the tides of Penobscot Bay.

Using the first two of these equations, since they belong to the largest components and have the most weight, for determining L and G, we get—

Port Townsend.	Astoria.	San Diego.
°	°	°
L=139.8	123.8	83.8
G=0.670^{d}	0.413^{d}	0.940^{d}

With these values of L and G for the several stations we get, from the third of the preceding equations, for the epochs of the P-component, 147°.3, 128°.4, and 94°.3, respectively which agree very well with those above, obtained from the analysis. In like manner we get from the last of those equations for the epochs at the several stations of the Q-tide, 122°.3, 113°.0, and 59°.1 respectively, the first two of which agree very well with those above, obtained from the observations. In the same manner the epochs in brackets have been obtained for the J-tide.

If the values of L and G had been obtained from all the equations by the method of least squares, they would have been slightly different and would have satisfied all the equations with very small residuals.

If to the values of G we add the difference of time between Washington and the several stations, we get the time by which the maximum of the diurnal tide follows that of the forces, that is, the time that the maximum of the tide depending upon declination follows the greatest declination, or that depending upon parallax follows the time of the greatest parallax. If in reducing the epochs by means of Table II the values taken from this table had been reduced to the time of the several stations, the value of G would have been the amount of this retard, without being reduced for the difference of time between Washington and the several stations.

18. *Semi-diurnal components.*—From the equations in section 33, of the Report on the Tides of Penobscot Bay, we have the three following for the three principal semi-diurnal components for determining the unknown constants E, F, and $\delta\mu$.

	Port Townsend.	Astoria.	San Diego.
S-tide,	.2461	.2682	$.4154=(.4582-36.2\delta\mu)(1+.4255E)F$
K-tide,	$.0716-0.2\delta\mu$	$.0762-0.3\delta\mu$	$.1180+0.3\delta\mu=(.1256-3.2\delta\mu)(1+.460E)F$
N-tide,	.2030	.1902	$.2421=.1922(1-.228E)F$

The first members of these equations are the amplitudes of the several tides, divided by the amplitude of the mean M-tide.

The values of the constants determined from these three sets of equations, and the moon's mass are—

	Port Townsend.	Astoria.	San Diego.
$E=$	-0.747	-0.635	-0.367
$F=$	0.903	0.865	1.1623
$\delta\mu=$	$.00164$	$.000906$	$.000936$
$\mu=$	$\frac{1}{70.8}$	$\frac{1}{74.6}$	$\frac{1}{74.4}$

The values for the moon's mass given by these equations, as is usual, for reasons already given, are considerably too large.

The valve of F for San Diego is greater than unity, which is the only case I know of in any part of the world. For very deep-water tides F should equal unity and E should be equal 0. This peculiar value of F must be caused by shallow-water components falling upon each of the several components, and thus increasing their values above what they should be with deep water.

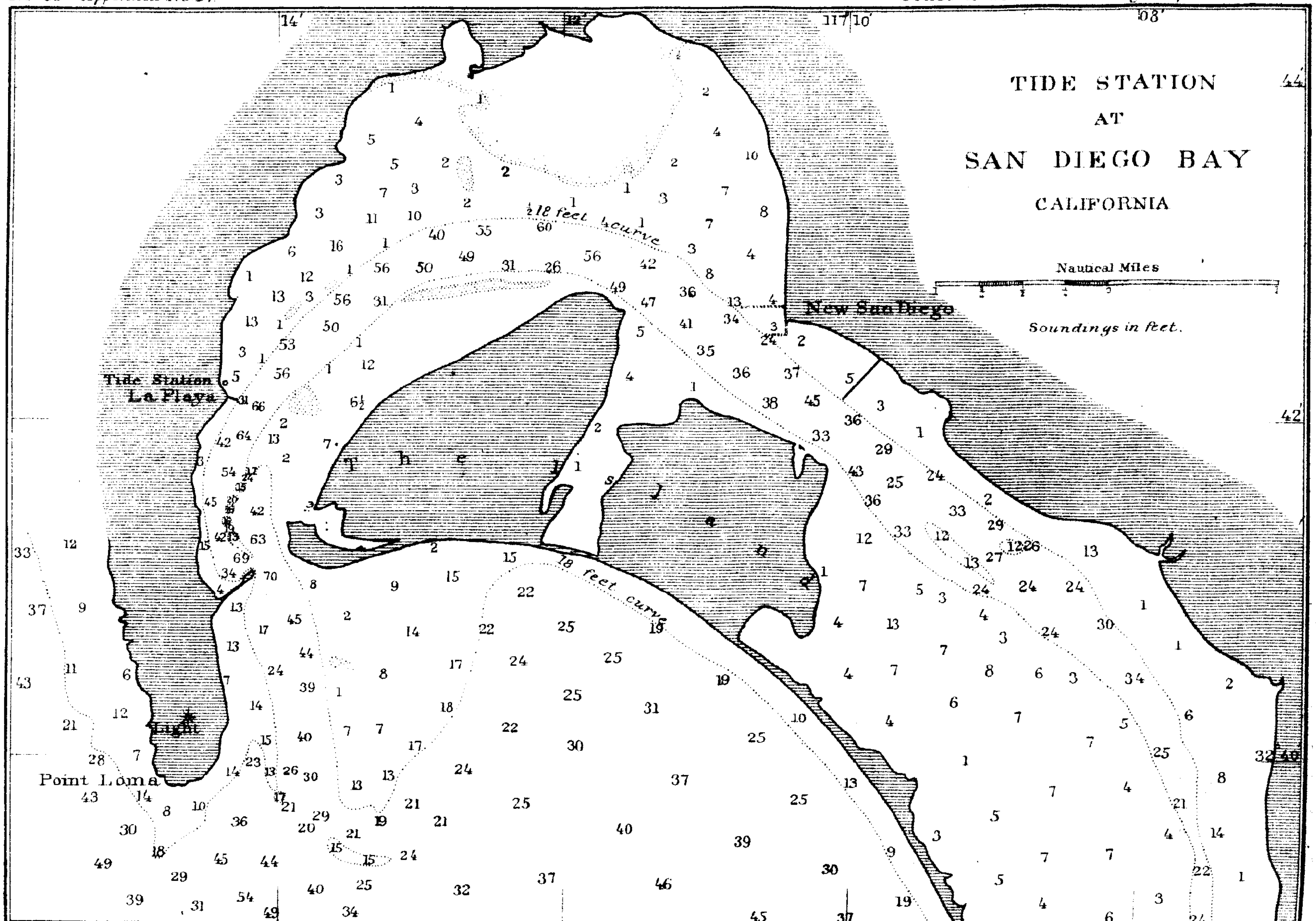
From section 34 of the report referred to above, we get for the two principal components the following three sets of equations for determining L and G.

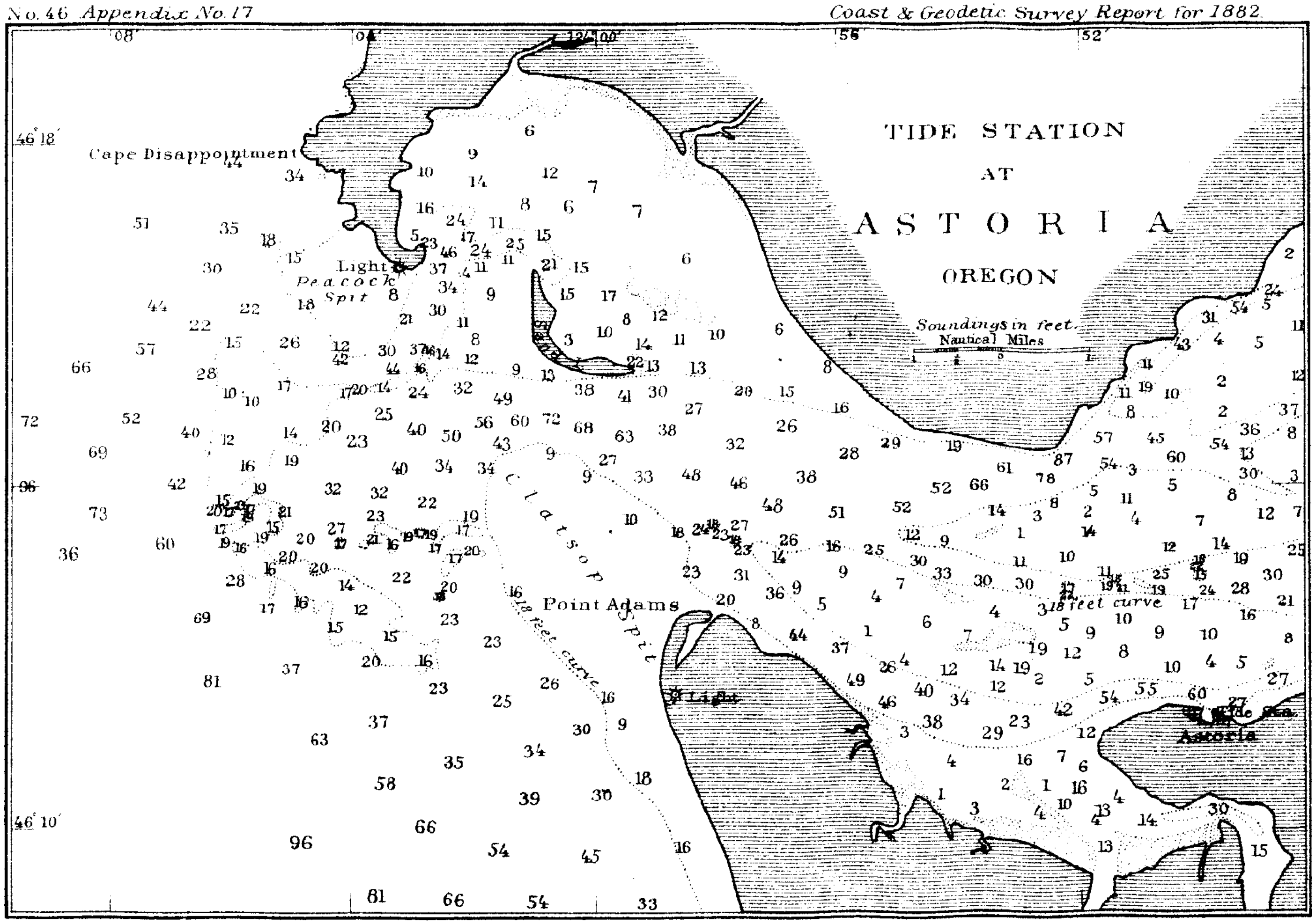
	Port Townsend.	Astoria.	San Diego.
M-tide,	$108^\circ.48$	$11^\circ.65$	$279^\circ.35=L.$
S-tide,	$129\ .47$	$39\ .5$	$274\ .58=L+24.4\ G$

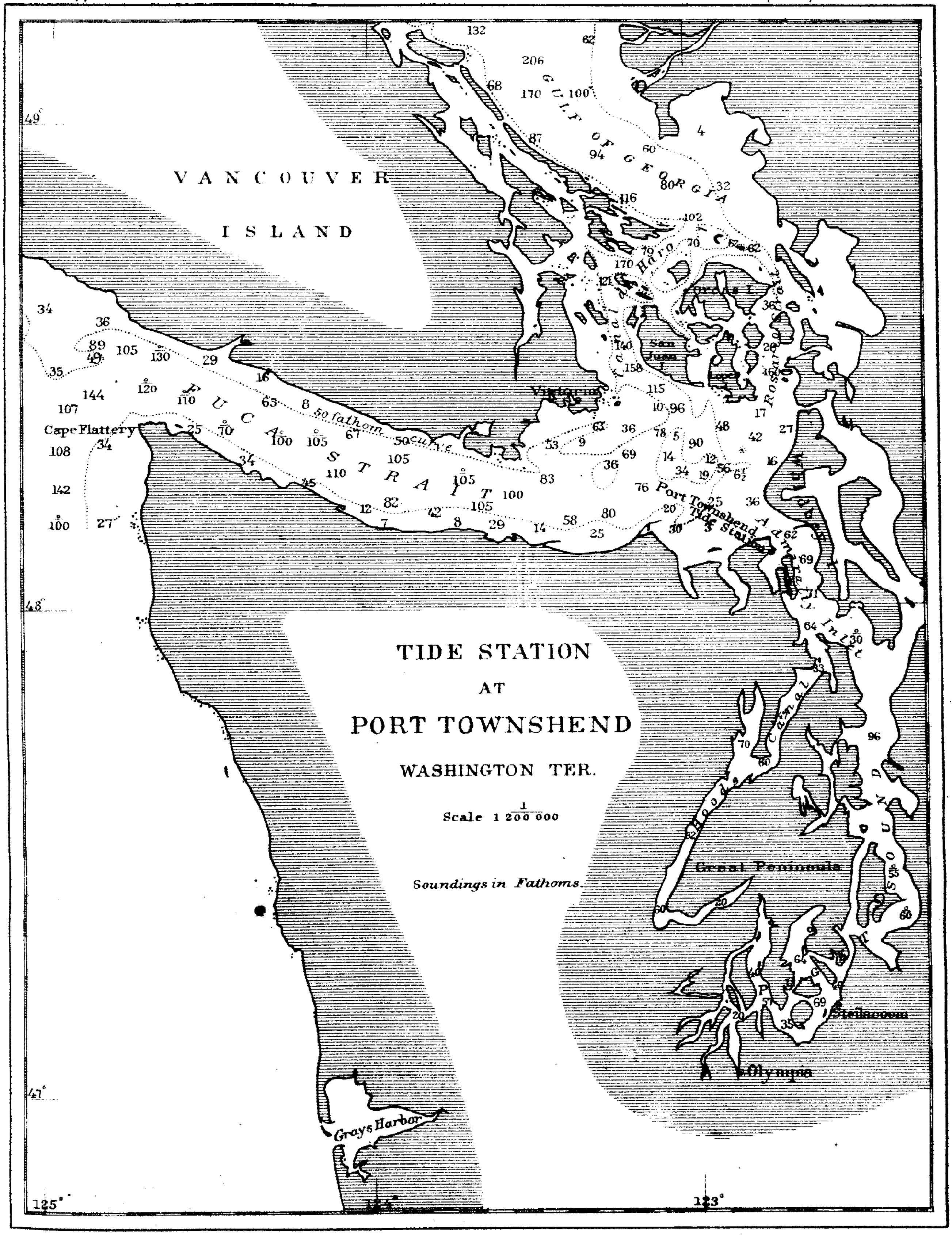
From these we get—

Port Townsend.	Astoria.	San Diego.
$L=108^\circ.48$	$11^\circ.65$	$279^\circ.35$
$G=\ 0\ .861^d$	$1\ .141^d$	$-0\ .196^d$

Adding to these values of G, for reasons given in the case of the diurnal tides, the difference of time between Washington and the several stations, we get the times by which the maximum of the tide follows the maximum of the forces. Adding the difference of time between Washington and San Diego, 0.112^d, to the preceding value of G for San Diego, we get -0.086^d, that is, the maximum of the tide occurs a little before the maximum of the forces. This is another peculiarity of the San Diego tides, and, although extremely rare, is a possible case in the theory of the tides.


TIDE STATION
AT
SAN DIEGO BAY
CALIFORNIA
Nautical Miles
Soundings in feet.
New San Diego
Tide Station
La Playa
Point Loma
Light
18 feet curve
18 feet curve
T h e I s l a n d
117°10'
14'
12'
08'
44'
42'


TIDE STATION
AT
ASTORIA
OREGON
Soundings in feet.
Nautical Miles
Cape Disappointment
Light
Peacock Spit
Clatsop Spit
Point Adams
18 feet curve
Astoria
46° 18′
46° 10′
124° 00′


TIDE STATION
AT
PORT TOWNSHEND
WASHINGTON TER.
Scale 1/1 200 000
Soundings in Fathoms
VANCOUVER
ISLAND
GULF OF GEORGIA
FUCA STRAIT
Cape Flattery
50 fathom curve
Victoria
San Juan
Port Townshend
Tide Station
Admiralty Inlet
Hoods Canal
Great Peninsula
Steilacoom
Olympia
Grays Harbor
49°
48°
47°
125°
124°
123°

APPENDIX No. 18.

REPORT ON THE SIEMENS ELECTRICAL DEEP-SEA THERMOMETER.

By Commander J. R. BARTLETT, U. S. N., Assistant Coast and Geodetic Survey.

(ACCOMPANIED BY A DESCRIPTION OF THE APPARATUS, BY WERNER SUESS.)

COAST AND GEODETIC SURVEY STEAMER BLAKE,
Providence, R. I., October 27, 1881.

SIR: In obedience to instructions received from C. P. Patterson, Superintendent, to experiment and report on the working of the Siemens deep-sea electrical apparatus furnished to this vessel, I have to report as follows:

The apparatus was set up on board the Blake, at Providence, in April, and several tests were made to see that all was in proper working order; the lower resistance coil was placed in a large tub of water at a temperature of 58° F. Water at 76° was placed in the copper vessel intended to hold the deck resistance coil. When the pencil of light was brought to zero on the scale by adding cold water to that already in the copper vessel, the attached thermometer read the same as the thermometer in the tub on deck containing the resistance coil, namely, 58°. Similar experiments were made with the same result. The arrangement of cable and connections has already been explained. My instructions for the season's work intended the use of the electrical apparatus for temperatures on the different lines, but owing to the non-arrival of a Carré ice machine, ordered from France, the apparatus was not used. My instructions were afterwards modified to limit the work of the season to soundings and bottom temperatures with the Miller-Casella thermometers.

Having completed the lines of soundings as laid out in instructions, I received orders to call at Fortress Monroe for the ice machine, and make experiments on my way to Providence.

I considered it very important to test the working of the apparatus in the strength of the current of the Gulf Stream off Charleston. I laid in a supply of ice at this port, and sailed on August 4, running a line over known depths. One of the 60-pound sinkers used in sounding was made fast to a becket, the latter seized to the insulated cable just above the lower resistance coil, and allowed to hang a short distance below. When well in the strength of the current, a series of temperatures were taken by the Miller-Casella thermometers on the sounding wire, and immediately after the insulated cable was lowered to the surface. Water from the surface having been placed around the deck resistance coil, the temperature of the attached thermometer read the same as that determined for the surface by the thermometer attached to the hydrometer case.

Under these conditions the pencil of light from mirror was on the zero of the scale. During the experiments the vessel was rolling from 10° to 15°, and there was a moderate breeze from southeast. The lower resistance coil was lowered to 5 fathoms below the surface, and was allowed to remain five minutes. The circuit being closed, the pencil of light remained at zero. Lowerings were made to 10, 20, and 30 fathoms. The deflection of the light was 15° at 10 fathoms. Temperature of attached thermometer when light was brought to zero, 76½°; that by the Miller-Casella thermometer the same. The deflection of light at 20 fathoms (reckoning from 76½°) was 12° on scale. Temperature reduced to 70¼°; by Miller-Casella, 69½°. The deflection at 30 fathoms was 2° from 70¼° temperature. Temperature by electric apparatus, 69½°; by Miller-Casella thermometer, 69°.

Five minutes were allowed at any depth for the resistance coil to assume the temperature of the water, and after reducing the water around the deck coil this was also allowed to remain five minutes before the final reading was taken. A common ice-cream freezer was used to reduce water below the freezing point, or to *frappé* it, and this was used for reducing the temperature of water around the deck coil.

The following table will give the results of the several lowerings:

Temperatures taken with Siemens electric apparatus and Miller-Casella thermometers in Gulf Stream, August 5, 1881.

Depth in fathoms.	Deflection of light on scale.	Reading of attached thermometer.	Reading of Miller-Casella thermometer.	Depth in fathoms.	Deflection of light on scale.	Reading of attached thermometer.	Reading of Miller-Casella thermometer.
No. 1.				No. 2.			
	°	°	°		°	°	°
Surf.	0	81½	81½	Surf.	0	81½	81½
5	0	81½	81½	30	+35	68½	....
10	+15	76½	76½	50	+ 8	65¼	65
20	+12	70¼	69½	75	+14	60	....
30	+ 2	69½	69	....	....	....	....
30	+23	68¾	68¾	....	....	....	....
No. 3.				No. 4.			
Surf.	0	83½	83½	Surf.	0	84½	84¼
30	+41	68	....	30	−12	81	80
50	+11	65¼	....	50	−30	75½	....
75	+13	60¾	....	75	−40	61¾	....
100	+10	56	54	200	+90	49½	49¾
150	+22	51	....	....	....	....	....
200	+13	47	47	....	....	....	....

The deflection of light to the left of zero is represented by the sign + ; deflection to the right by the sign —.

We could not see to work the cable after dark and were obliged to give up further observations. The several lowerings were taken 5 miles apart on a line across the stream.

The rolling of the vessel, which was considerable, affected the mirror so as to throw the light about 5° each side of the zero point when at rest, and nearly the same when the current was closed, but as the deflection was the same each side, it was easy to determine the middle point. While at work in the current it was necessary to work the engine in order to keep the wire up and down. The jar of the engine affected the mirror to such a degree that readings could only be taken when the engine was stopped.

The Carré ice machine having been received on board at Fortress Monroe, we sailed from Hampton Roads August 10, steaming to the eastward until reaching the meridian of 74° 30′ W., when a sound was taken giving a depth of 1,024 fathoms. A serial was taken to a depth of 400 fathoms with the Miller-Casella thermometers. The thermometers on hand were very carefully compared with the standard, and only two were found that would record accurately at different temperatures. Only these two thermometers were used in taking the serial. Immediately after the serial with the thermometers, the insulated cable was lowered into the sea and the temperature by the galvanometer and upper resistance coil recorded for the same depths as taken in the first serial. Five minutes was allowed at 5 and 10 fathoms, but there was no deflection of the pencil of light. The temperature of the surface was 76½°. Having lowered to 15 fathoms, at the end of one minute the pencil of light was 9° to the left of 0 on the scale. At the end of 5 minutes it was 22°, and at the end of 10 minutes still 22°. A number of experiments were made with regard to the time necessary for the resistance coil to assume the temperature of the water at the point to which lowered. Five minutes was decided on as the time necessary, and this time was adopted for all future depths. The deflection of light cannot be used as a measure for the difference in temperature, as the temperature of the deck resistance coil does not remain a constant during the lowering of the cable, but the temperature rises according to the elapsed time. The first lowering was to 400 fathoms, the temperature being at that depth 40°. The cable was then reeled in to 200 fathoms, when the circuit was made. The pencil of light was at zero, the water in the copper vessel having risen from 40° to 43½°. This temperature agreed with that at 200 fathoms when lowering to the same depth.

We were from 7.18 p. m. until 1.30 a. m. taking the temperatures to 400 fathoms and return. This was a very long time, but every reading was taken with the greatest possible care. For a serial with the electric apparatus, fifteen minutes for each depth would be a fair average.

Following are the serials taken August 11:

Depth in fathoms.	Temperatures by Siemens apparatus.	Miller-Casella thermometers.	Depth in fathoms.	Temperatures by Siemens apparatus.	Temperatures by Miller-Casella thermometers.
	°	°		°	°
Surf.	76½	76½	30	54	54
5	76½	76½	50	54¼	53½
10	76½	76	100	50½	50½
15	69	68	150	46½	46½
20	58	58	200	43½	43½
30	54¼	54	....	....	....
50	54¼	53½	....	....	....
75	52½	52½	....	....	....
100	51	50½	....	....	....
150	46	46½	....	....	....
200	43½	43½	....	....	....
300	40½	40½	....	....	....
400	40	40	....	....	....

Deflection of light: ° °

At 15 fathoms .... 22 from 76½
At 20 fathoms .... 27 from 69
At 30 fathoms .... 12 from 58
At 50 fathoms .... 0 from 54¼
At 75 fathoms .... 3 from 55
At 100 fathoms .... 9 from 54
At 150 fathoms .... 29 from 54½
At 200 fathoms .... 22 from 54½
At 300 fathoms .... 5 from 43
At 400 fathoms .... 3 from 42¼

At 200 fathoms there was a delay in lowering the cable, which allowed the deck water to assume a higher temperature. In reeling back we stopped at 200 fathoms.

Deflection of light: ° °

At 200 fathoms .... 0 from 43½
At 150 fathoms .... 3 from 48

While the above experiments were being carried on there was a light southeast breeze, with a very smooth sea, and before morning it had become calm, and so continued during the experiments.

Early on the morning of August 12 a serial to 600 fathoms was taken, and immediately after the same depths by the Siemens apparatus.

The following are the temperatures obtained in lowering and reeling in:

Depth in fathoms.	Temperatures by Siemens apparatus.	Miller-Casella thermometers.	Depth in fathoms.	Temperatures by Siemens apparatus.	Miller-Casella thermometer.
	°	°		°	°
Surf.	76	76	Surf.	77½	77½
5	76	75¼	5	76¼	75¼
10	73½	69	10	75½	69
15	61¼	68	15	66½	63½
20	55½	59	20	58	57
30	51	52½	30	51½	51½
50	53¾	52	50	54½	53½
75	52½	52½	75	53½	52½
100	50	49½	100	51	49½
....	....	....	125	48¼	....
....	....	....	150	46¼	46
....	....	....	200	43½	43¼
....	....	....	300	40½	40¾
....	....	....	400	40	39¾
....	....	....	500	39¼	39
....	....	....	600	38¾	38¾
....	....	....	700	38½	38½
....	....	....	800	38½	38½

The deflection of light was 6° from 76° at 10 fathoms. The deflection at 15 fathoms was 21° from 73½°. At 20 fathoms, 11° from 61°. At 30 fathoms, 10° from 56°. At 50 fathoms, the deck resistance being 51°, the deflection was to the right 11°, and the temperature of the water was found to be 53¾°, nearly 3° higher than at 30 fathoms. At 75 fathoms the deflection was 3° from 54°. At 100 fathoms it was 8° from 53°. From 100 fathoms the cable was lowered without stopping to 800 fathoms; the circuit being made the deflection of light was 100°, the deck resistance being in a temperature of 75°. At 700 fathoms the deflection was 7°, the temperature of deck resistance having risen to 42½°. At 500 fathoms the deflection was 10° from 54°. At 400 fathoms the deflection was 0, the deck resistance temperature having risen to 40°. At 100 fathoms the deflection was 5° to the *right* from 49°.

In reeling back the cable the temperature at 50 fathoms was 54½° and fell to 51½° at 30 fathoms.

Immediately after the experiments with the Siemens apparatus, another serial was taken with the Miller-Casella thermometers. In this serial the Miller-Casella thermometers indicated the same change in the water from 30 to 50 fathoms. The Miller-Casella thermometers were lowered to 30 and 50 fathoms continually, and always gave the temperature at 50 fathoms higher than at 30 fathoms. The cable was lowered three separate times to 50 fathoms, the readings being taken both when lowering and reeling in, with the following results:

Depth in fathoms.	Temperatures by Siemens apparatus.	Temperatures by Miller-Casella thermometers.	Depth in fathoms.	Temperatures by Siemens apparatus.	Temperatures by Miller-Casella thermometers.
	°	°		°	°
Surf.	77½	77½	....	....	....
20	57¼	57	30	51¾	52
30	52¼	52	50	54½	53½
50	55¼	53½	75	53	52½
20	57¾	57	....	....	....
30	52¾	52	....	....	....
50	54¼	54	....	....	....
75	53	52½	....	....	....

While the above experiments were being conducted the sea was perfectly smooth, with no wind. The ship's engine was not used at all, the vessel lying almost motionless in the water. The temperature of the deck resistance coil was reduced by water from a carafe, the water contained therein having been frozen by the Carré ice machine. Two carafes were prepared at a time, and there was plenty of time to keep one constantly at hand.

The pencil of light used covered one degree of space on the scale.

In lowering the cable with the circuit closed, the light would move to the left on the scale, and at least five minutes were necessary for it to become stationary.

In order to have the Miller-Casella thermometers record the high temperature at 50 fathoms at the last experiments, they were lowered very rapidly to that depth, and after eight minutes reeled back at the rate of 200 fathoms per minute, so that the minimum side did not have a chance to assume a lower temperature.

I have always had trouble with the Miller-Casella thermometers in recording temperatures above 70°, but in my long experience with them have always felt confidence in the many temperatures that I have obtained below 70°, and it is a great satisfaction to have these temperatures confirmed by the electric apparatus.

The cable containing the insulated wire is very loosely laid up, and in the few lowerings that we have made has become long-jawed. The parceling around the cable is very poor, and the slightest chafe rubs it off. The apparatus could not be used constantly, as the constant paying out and reeling in would soon part the copper wires; but as an instrument of precision I consider it a great success. More confidence may now be placed in the Miller-Casella thermometers, and at certain times on each line the electric apparatus could be used to verify the temperatures, and show any underlying warm strata of water. All parts of the apparatus worked to perfection, but it is necessarily very slow work in taking a serial to any great depth.

The cable was led from the large reel through an 18-inch iron leading block, with a 60-pound shot as a sinker. It was lowered and reeled in very slowly and without jerks.

Respectfully,

J. R. BARTLETT,

Commander, U. S. N., Assistant Coast and Geodetic Survey.

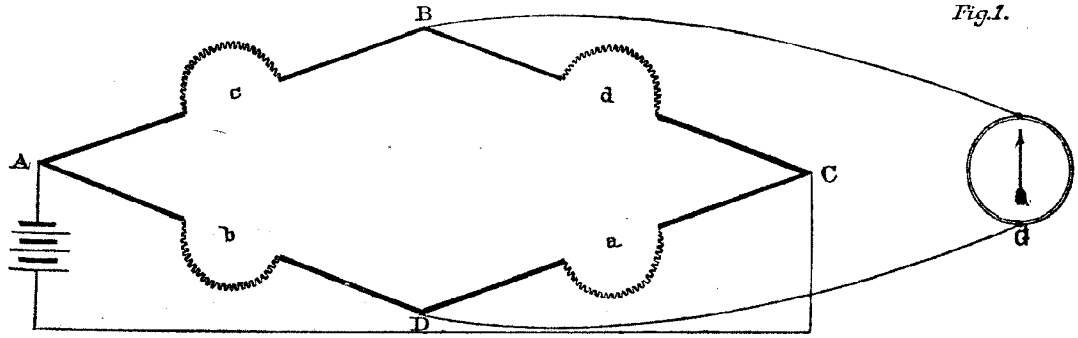
Mr. J. E. HILGARD,

Assistant in Charge of Coast and Geodetic Survey.

WERNER SIEMENS DEEP-SEA THERMOMETER.

The various methods of determining the electrical conductivity of a metallic wire consist essentially in ascertaining what length of a given section of the wire will offer the same resistance as that length of a metallic wire of a given section taken as a standard of comparison. A description of the principle of one of those methods, known as Wheatstone's balance or bridge, will give a general idea of them.

Fig.1.



On a base of hard wood, four stand wires are fixed, in the manner represented in the above figure. They are provided with binding screws, A, B, C, and D, and there are breaks at *a*, *b*, *c*, and *d*, also provided with binding screws, so that any resistances may be introduced there. The points A and C are connected with the battery, while B and D are connected with a delicate galvanometer. Now it can be shown that, if the resistances introduced at *a*, *b*, *c*, *d*, and which we will designate by these letters, bear a certain relation, no current will pass in the galvanometer.

Suppose, first of all, that the resistances are all equal in every respect; the current arriving at A would divide, one part would traverse the galvanometer in the direction A, *c*, B, G, D, and the other in the direction A, *b*, D, G, B, and as both of them are equal and opposite in direction, no effect would be produced on the galvanometer; but if the resistances *a* and *b* are different, the tensions of B and D will be different, and accordingly a current will traverse the galvanometer either from D to B or from B to D, and the needle will be deflected accordingly.

The principle of the deep-sea thermometer is based upon the *variation* which changes of temperature produce in the resistance of metals to the passage of an electrical current.

The apparatus consists of a resistance coil which is lowered into the sea by means of a cable to the depth at which the temperature is to be measured. The other end of the cable is attached to a Wheatstone bridge, specially arranged for this purpose. Another coil, of the same material and resistance as that lowered into the sea, is likewise attached to the bridge, with a battery and galvanometer. By sending a current into the bridge a deflection of the galvanometer needle will be noticed, showing that the temperature of the comparison coil is either too high or too low, according to the direction of the deflection. By altering the temperature of the coil, a point must be reached when no deflection can be observed on the galvanometer. The temperature then indicated by the mercurial thermometer attached to the coil is the same as that of the coil lowered into the sea.

FIG. 2.

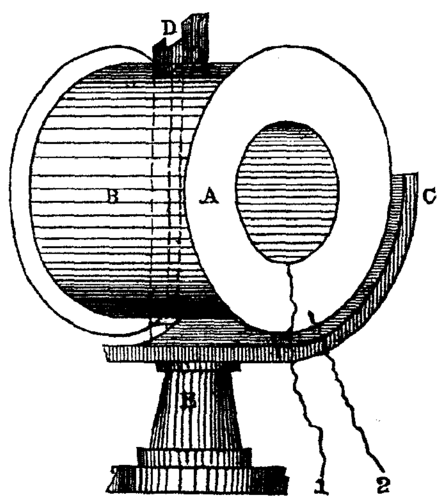
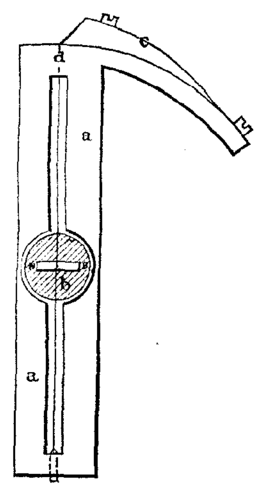


FIG. 3.



The galvanometer used is Thomson's reflecting marine galvanometer. It consists of a perforated coil of fine insulated wire resting in a large horseshoe magnet, *c*, one-half of which is shown in the accompanying figure (Fig. 2). Into this coil is inserted a holder, D, for the frame carrying the reflector. This frame is shown in the other figure. It is made of brass and has a broad slit in which the small concave mirror, or reflector, is suspended by means of a silk fibre; the spring *c* keeps the fibre in a state of tension. The mirror has a focus of about 2 feet, so that the image of an illuminated slit can be thrown on a graduated scale mounted at that distance in front of the coil. A small magnet attached to the back of the mirror is deflected when the temperature of the two resistance coils is unequal, and the direction and amount of the deflection is indicated on the graduated scale by the concave mirror.

The special Wheatstone bridge apparatus is connected as shown in illustration No. 49.

The zinc pole of the battery must be connected to the terminal marked Z, and the carbon pole to the terminal C. To the terminal E is connected an insulating wire leading from the testing-room to the deck; to the other end of this wire will be attached a copper-wire rope, which must be dropped over the ship's side into the sea. The two terminal pillars of the galvanometer, marked G and C, are to be connected with the corresponding terminals of the Wheatstone bridge. To the terminals T and T connect the ends of the comparison coil, which will be immersed in a copper vessel containing water. The two wires of the cable, marked L C and E C, must be joined to the terminals similarly marked on the apparatus; the other ends are attached to the sinker.

On lowering the sinker over the side an alteration in its temperature will take place, and if the key marked K on the Wheastone bridge apparatus be depressed, a deflection of the spot of light along the galvanometer scale will announce the fact, the direction of the deflection showing the direction of the alteration, and the amount of deflection its extent. The key should be held down a few seconds, and the permanent deflection only taken into account, as on first depressing the key a sudden throw of the galvanometer needle will always be produced by the electro-static charge of the cable. The permanent deflection remaining after the cable is charged is that due to the difference between the resistances of the comparison coil and the sinker.

If the temperature of the comparison coil in the testing-room is too high, the deflection will be to the left, *i. e.*, the operator's left as he faces the scale, and in the same manner a deflection to the right will denote that the temperature of the coil is too low.

Illustration No. 48 shows the connection of the sinker and its resistance coil with the two insulated wires of the cable. The wire L C is connected with the upper end of the resistance coil inclosed in an iron tube with flanges and caps, while the other end of the coil is soldered into a slot in the bottom cap. The other end of the cable, which will be of course E C, is soldered against the body of the sinker, thus connecting the end of the core E C to the earth.

SKETCH SHOWING THE CONNECTION OF THE SINKER AND ITS RESISTANCE COIL WITH THE TWO INSULATED WIRES OF THE CABLE

Scale: half size

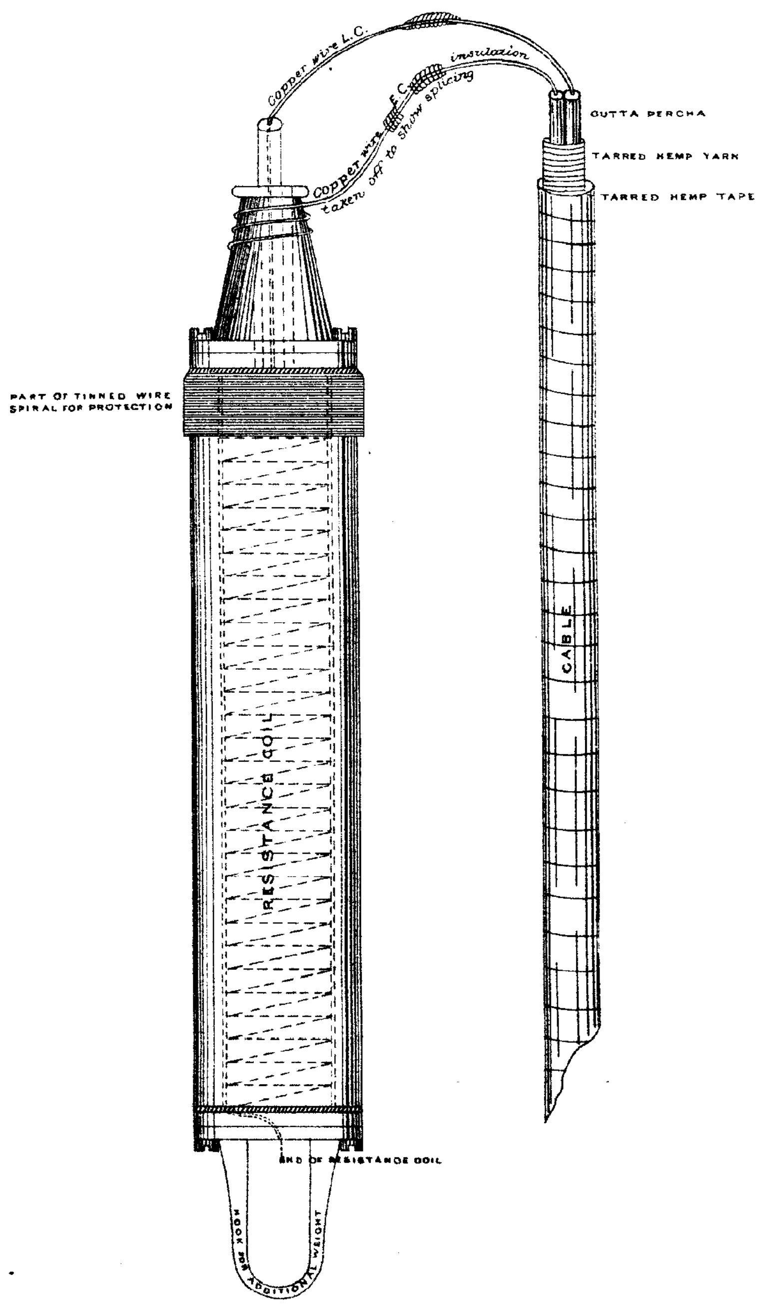
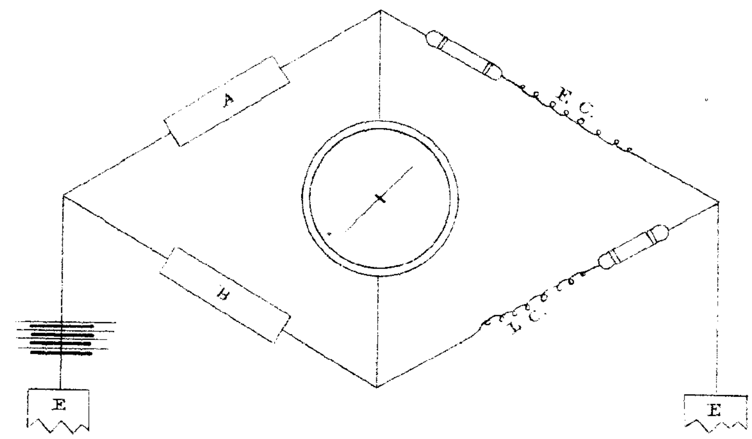
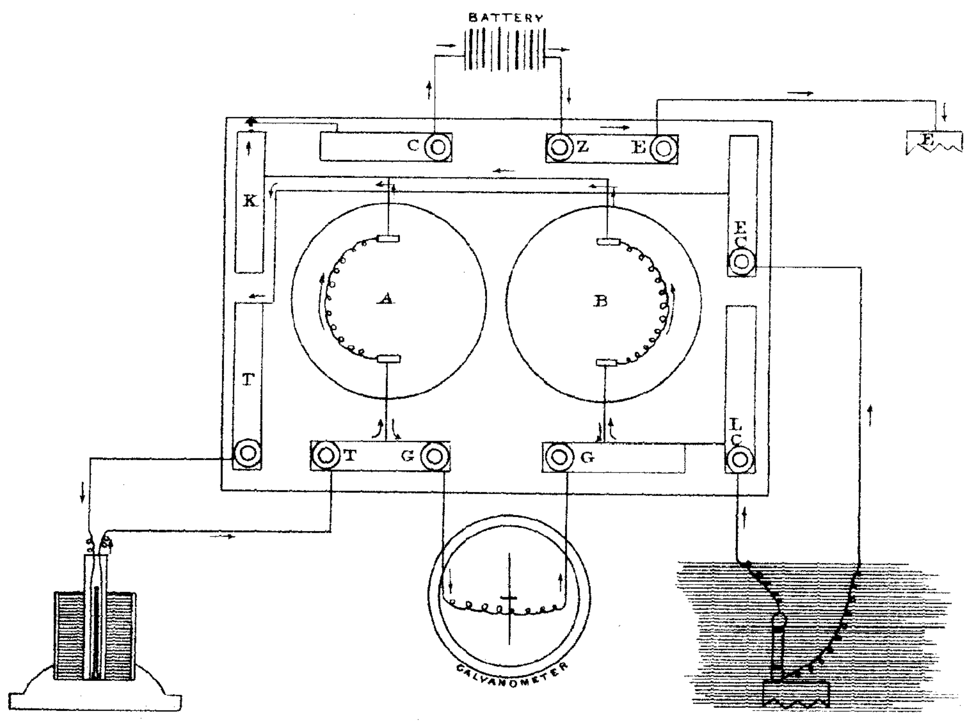


DIAGRAM SHOWING WHEATSTONE BRIDGE APPARATUS AND CONNECTIONS



SIEMENS ELECTRICAL DEEP SEA THERMOMETER



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APPENDIX No. 19.

RECENT DEEP-SEA SOUNDINGS OFF THE ATLANTIC COAST OF THE UNITED STATES.

By Lieutenant J. E. PILLSBURY, U. S. N., Assistant Coast and Geodetic Survey.

DEAR SIR: In accordance with your request, I have to submit a general summary of the operations of the Coast Survey steamer Blake in the examination of the Western Atlantic basin during the years 1880, 1881, 1882, and 1883.

The cruise of the Blake, under Commander J. R. Bartlett, during the winter of 1879-'80, in the Caribbean Sea, was really the commencement of the systematic examination of the Western Atlantic basin; for, in the development of the dividing ridge between the Atlantic and the Caribbean, the soundings were carried outside sufficiently far to show the contours up to 2,000 fathoms from Barbadoes to San Domingo, and, continuing, the passage between the Greater Antilles and the Bahamas was developed. The following year (1880) Commander Bartlett sailed, May 27, under instructions dated May 12, indicating the points at which lines of soundings, dredging, and temperatures were to be obtained.

The lines were to be run about normal to the coast and extending from the vicinity of Charleston, S. C., to George's Bank. The special object of the cruise was dredging, but serial temperatures and soundings were, of course, to be included in this work.

A commencement was made with the line off Charleston, and this line revealed at once the remarkable and unexpected character of the bottom. The first sounding and haul was made in 142 fathoms, about southeast of Cape Romain. After this they steamed to the eastward, taking frequent casts to find the depth at which it was desired to dredge, but, to their astonishment, the water would not deepen as they expected, and they had crossed the imaginary axis of the Gulf Stream before getting 300 fathoms at any sounding.

In his report Commander Bartlett says: "The bottom was hard coral rock, but the cylinder always brought up small fragments of coral. We found but very few traces of animal life on this bottom, but made good hauls on its edge. For 15 miles or more from the 100-fathom line we found a very strong current setting to the southwest. When the trawl was down we tailed in that direction and dragged at the rate of two knots without steam. When in the Gulf Stream we found the current to the northward and eastward 2.6 knots per hour. The water deepened east of the axis of the stream to 382 fathoms, but shoaled again to 337 fathoms. As the instructions received from the Superintendent were to confine ourselves to dredging, these soundings were not continued, but the stream was followed along its axis to the northward, soundings being taken every five miles," with the result that no depth was obtained over 500 fathoms until the vessel had reached a point off Cape Lookout.

The following year it was determined to develop the bed of the Gulf Stream from the point of its departure from Florida Straits to the northward of Cape Hatteras, and detailed instructions were issued, dated April 12, 1881, to Commander Bartlett. The lines were intended to be at intervals of about 60 miles, run normal to the general trend of the coast, and to extend completely across the area swept by the Gulf Stream. It was originally the intention to obtain serial temperatures at certain intervals, but it was found that, in order to make perfect lines of soundings, it was necessary to have the best of weather and to remain under the influence of the Gulf Stream current as short a time as possible, and therefore it was unadvisable to do more than obtain the depth, the bottom-soil specimen, and the temperature at the bottom and surface, and to leave the study of the intermediate temperatures to a future date.

The lines run during this season developed a plateau extending from Cape Hatteras to the Bahama Banks, the depths increasing but slowly until about 500 fathoms, after which they increase rapidly to the Great Atlantic basin, at a depth of between 2,000 and 3,000 fathoms. Commander Bartlett in his report of this season, after its completion, says: "The eighteen lines of soundings run normal to the coast from Jupiter Inlet, Florida, to Currituck, N. C., by the steamer Blake, and the observations taken by the hydrographic party under my command, give very interesting data in regard to the physical features of the bottom of the ocean over which the Gulf Stream flows. Instead of a deep channel, which has previously been reported, our soundings show an extensive and nearly level plateau extending from a point to the eastward of the Bahama Banks to Cape Hatteras. Off Cape Canaveral it is nearly 200 miles wide, and gradually decreases in width to the northward until reaching Hatteras, where the depth is more than 1,000 fathoms within 30 miles of the shore. This plateau has a general depth of 400 fathoms, suddenly dropping on its eastern edge to 2,000 fathoms. The soundings in the strength of the current were all taken with the 60-pound shot sinkers, the time allowed for the sinker to reach the bottom being less than one minute to each 100 fathoms in depth. Most of the soundings taken each side of the steamer when not in strong current were taken with a 36-pound lead on the sounding wire, the lead being reeled back. * * *

It will be observed from the bottom specimens that the course of the current can almost be traced by the character of the bottom soil. On each side of the stream the sounding cylinder brought up ooze. In the strength of the current the bottom was washed nearly bare, the specimens being small broken pieces and particles of disintegrated coral rock. This bare portion was very hard and the sharp edge of the brass sounding cylinder came up very much dented and defaced.

From Jupiter Inlet, with the exception of the bare part mentioned, the specimens were a light-colored ooze, composed of Pteropod shells with a mixture of coral sand. Off Charleston, where the plateau has a less depth than to the southward, the bare section extended the whole width of the stream. The Pteropod ooze extended only to Charleston. To the northward of that point the specimens were of Globigerina ooze of a dark greenish tint."

It would seem probable that the general circulation of the Arctic and Equatorial currents might be ascertained by the character of the bottom specimens.

In the Gulf Stream, the current was found to average about 3 knots, but at times it was as high as 5.4 knots per hour. Temperatures were taken at the surface (the water being drawn over the stern) every mile, and at the bottom at nearly every sounding.

The surface temperature varied considerably with the weather; one day, which was calm, it even rose to 89°, but the average was found to be not far from 83° between Jupiter and Hatteras. The general average temperature of the bottom of the stream is 45°, and a little less on each side.

On the Charleston section it rose as high as 50° in 350 fathoms, but in a 500-fathom hole on this section it fell as low as 38°.

The thermometers were the Miller-Casella self-registering pattern. The Negrette-Zambra, which depends upon the buoyancy of its wooden case to register, became so water-logged and crushed by the pressure, that it gained 10 ounces in weight; its specific gravity, therefore, being greater than the water, it failed to register correctly.

During the early part of the following summer (1882), Commander Bartlett ran a line of soundings and temperatures from Block Island to Bermuda Islands and a line of serial temperatures from thence to Cape Hatteras. In the deep water near the cape the temperature when in the Gulf Stream was about the same as at equal depths on the Chaerlston plateau or in the Gulf of Mexico or the Caribbean Sea, but farther to the northward, where the stream is deflected to the eastward, and has room to spread out, the depths of equal temperatures approached nearer the surface.

Lieut. Commander W. H. Brownson succeeded Commander Bartlett in July, and after running one or two lines from Nantucket and from the Georges Bank across the Gulf Stream, engaged in the work of developing the approaches to New York. The orders issued contemplated a survey of the broad plateau of the New York entrance, from Block Island to Cape May, and extending seaward as far as deep water. One of the interesting features of the examination made during this season was the discovery that the spot hitherto known and shown on the Coast Survey charts as the 145-fathom hole, was in reality a very much deeper spot, 474 fathoms having been found in it. At this date (June, 1883) the vessel is engaged in completing the survey, but the data will not be ready for final examination until next month.

This is one of the many so-called holes which are found at irregular intervals, extending from Sandy Hook.

There seems to be another hole about 200 miles farther to the southwest; its depth is over 3,000 fathoms, the surrounding depth being very much shoaler.

During the past winter the Blake has been engaged in developing the limit and general character of the Great Atlantic Basin between Bermuda and the Bahamas, and along the outside of the West India Islands as far to the eastward as Saint Thomas. This cruise has been of great interest. The bed of the Western Atlantic is shown to have a general depth of about 2,700 or 2,800 fathoms, and so abrupt is the slope that at some places depths of over 2,000 fathoms are found almost, if not quite, in sight of the islands along the outside of the Bahamas, and even in the narrow passages between them.

In one instance the 2,000-fathom curve was found to approach the shore to within $2\frac{1}{2}$ miles, giving an inclination of the bottom for this distance of about 38°, and for a part of the distance it was found to be 45°.

Not the least gratifying point of interest in this cruise was the successful sounding taken at the depth of 4,561 fathoms, which, it is believed, is the greatest depth from which bottom soil specimen and temperature have been obtained. The temperature was $36\frac{1}{4}$°. Soil specimen, brown ooz

Very respectfully, yours,

J. E. PILLSBURY,
Lieut. U. S. N., Acting Hydrographic Inspector.

Prof. . E. HILGARD,
Superintendent U. S. Coast and Geodetic Survey, Washington, D. C.

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APPENDIX No. 20.

THE TOTAL SOLAR ECLIPSE OF JANUARY 11, 1880, OBSERVED AT MOUNT SANTA LUCIA, CALIFORNIA.

By GEORGE DAVIDSON, Assistant.

U. S. COAST AND GEODETIC SURVEY,
San Francisco, Cal., January 16, 1880.

DEAR SIR: After computing the central line of totality of the solar eclipse of January 11, I decided to occupy the triangulation station of the Coast and Geodetic Survey, Mount Santa Lucia, about 5,700 feet elevation, in latitude 36° 08′ 20″ north and longitude 121° 24′ 30″ west of Greenwich, and lying 35 miles southeast from Point Pinos. This station is only 12 or 15 miles from the coast line, but is separated from the mountains immediately overlooking the shore by the deep, narrow valley of the San Antonio, which flows southward to join the Salinas River flowing to the northward. There is another mountain on the Coast Range, lying near the path of central totality, about 10 miles farther to the westward and 5,000 feet elevation, but it is well-nigh inaccessible. On the triangulation reconnaissance it is known as Cone Peak.

Although the ascent of Santa Lucia Mountain is somewhat difficult, I was very well satisfied with the selection and the advantages which it afforded.

In this work the party consisted of Assistants Gilbert and Colonna, Subassistant Dickins, myself, my son, and four hands. Our outfit was of the simplest character, although we expected snow and heavy weather at that elevation and season.

The instruments were:

Equatorial, $6\frac{7}{16}$ inches (with star spectroscope), portable observatory, canvas dome (George Davidson).

Hassler equatorial, 3 inches, United States Coast and Geodetic Survey.

Zenith telescope No. 1, $2\frac{7}{8}$ inches, United States Coast and Geodetic Survey.

Meridian instrument No. 1, $2\frac{7}{8}$ inches, canvas observatory, United States Coast and Geodetic Survey.

Reconnoitering telescope No. 24, $2\frac{1}{2}$ inches, United States Coast and Geodetic Survey.

With chronometers, sextant, barometers, thermometers, solar-radiation thermometers, binoculars, &c.

Professor Frisby, from the United States Naval Observatory, asked my advice in San Francisco about the best location, facilities, &c. I freely gave him all the information I had, and as his funds were very low, and he had no camp outfit whatever, I invited him to occupy the same station, and promised that we would carry his instruments, &c., with ours, he bearing a proportion of the general expense. He accepted the proposition.

The Southern Pacific Railroad, through Mr. Bassett, ordered every facility to be granted my party in the transportation of the instruments, &c.

Through the active kindness of H. M. Newhall, esq., of San Francisco, I was enabled to obtain transportation by teams and animals and the services of his majordomo, Mr. Fancher, to move from Jolon to the base of Santa Lucia.

Mr. Colonna, with Professor Frisby, examined the approaches to the mountain, and after a second examination by Mr. Colonna the best available trail was chosen. It is very steep and rough, and the total rise is about 4,000 feet in three or four miles. When the station is occupied for the triangulation the trail can be zigzagged in some of the steepest rocky places. At Camp Milpitas (latitude by sextant 36° 05′ 54″) which the wagons reached, we kept the pack animals, on account of the severity of the weather and the necessity of getting fodder from Jolon.

The summit of Santa Lucia is in two peaks, about 200 yards apart, with a saddle or depression of 20 feet between them. The eastern one will doubtless be chosen for the triangulation; we chose the western one for the eclipse work as affording us protection for the tents and a near supply of fire-wood.

Mr. Gilbert secured the base for the large equatorial, and assisted in mounting it.

Mr. Colonna with Mr. Dickins prepared the block and observing tent for the meridian instrument which was used for transit observations and for latitude.

With the sextant I observed for latitude, but the heavy weather came upon us before the instruments were fairly mounted; fierce winds, rain, sleet, and snow making everything very uncomfortable. The temperature was mostly below freezing, and upon one night, when Mr. Colonna was observing, the thermometer recorded 11½°, with a bitter north wind blowing. When we first reached the mountain the earth was frozen to a depth of 6 inches, which increased before we left. But the weather cleared up on the afternoon of the 10th, and Sunday (the 11th) opened clear and cold, with the temperature at 15° and a stiff north wind. To this time Mr. Colonna had determined the errors of the chronometers by transit observations, and also the latitude by two nights' observations upon seven pairs of stars. When opportunity afforded, I had observed for time and latitude with the sextant.

To check the longitude of the mountain as given on the reconnaissance plan, Mr. Dickins made a round of horizontal angles upon all known points.

The view from Santa Lucia is uninterrupted: Point Arguellois distinctly visible at 90 geographical miles distant. To the west the ocean is visible except where obstructed by the summit of Cone Peak.

I could have selected a point in the Salinas Valley on the line of totality, but I was afraid of the valley fogs, of which there were several on days when the mountains were clear.

My plan of operations was to observe the beginning and ending of the eclipse, the beginning and ending of totality; but the latter by only one or two observers, whilst the rest sketched the corona and looked out for intramercurial planets. By rising to this elevation I had computed that the ending of the eclipse would be visible.

I had interested parties in the Salinas and San Antonio Valleys to note whether the eclipse was total at Soledad on the northern limit, and have verbal reports and expect others.

Of course I determined to look for intramercurial planets, and had five star charts prepared for the purpose, one for each observer who studied the relative position of the probably visible stars. The equatorial zenith telescope and meridian instrument would have given absolute positions, had such objects been detected.

Diagrams were prepared upon which to sketch the corona, rose-colored flames, &c.

As the computed time of totality was only 33½ seconds, the chances for our doing much in either of the last two schemes were infinitely small; nevertheless I felt sure of doing something trustworthy.

The observers were as follows:

Assistant Davidson: $6\frac{7}{16}$-inch equatorial. Power estimated 300; colored glasses show sun greenish yellow; Herschel prism; solar eye-piece.

Assistant Gilbert: United States Coast Survey Hassler equatorial, 3 inches. This is the instrument with which I observed the solar total eclipse of August 7, 1869, in Alaska. Direct eye-piece, power about 100; colored glass, neutral tint.

Assistant Colonna: United States Coast Survey meridian instrument No. 1 turned out of the meridian. Objective $2\frac{7}{8}$ inches; direct eye-piece with prism, power 60; colored glass shows sun red.

Subassistant Dickins: United States Coast Survey zenith telescope No. 1. Objective $2\frac{7}{8}$ inches; direct eye-piece with prism, power 85; colored glass shows sun greenish orange.

George F. Davidson: United States Coast Survey reconnoitering telescope No. 24. Objective $2\frac{9}{16}$; direct eye-piece, power about 40, showing whole sun in the field; colored glasses show sun greenish orange.

I had taken with me two chronometers; obtained the use of a third from Professor Frisby; used pocket chronometer Widenham 900, and a watch. All were compared by Mr. Colonna before, during, and after the eclipse.

Mr. Colonna had good transit observations, and a good determination of the latitude which I had, by sextant observations, placed in 36° 08′ 20″, and from the reconnaissance sheet in 121° 24′ 30″.

Sunday, January 11.—The morning was remarkably clear and the atmosphere very steady, with a cold and moderately strong wind from the north. Temperature 15°. No clouds were visible except a low bank about half a degree higher on the western horizon. The instruments were all in position on the western side of the summit, and protected from the wind to prevent vibration.

As the time of first contact approached I gave warnings at 5, 4, 3, and 2 minutes before the computed time. Each observer watched to see if he could perceive the moon's disk before it touched the sun; but it was not seen.

The limb of the sun was not absolutely steady, but nearly so, and sharply defined. The three clusters of spots were well made out in all the telescopes, although some of the individual spots were very minute; the penumbræ were well marked and defined; the mottled appearance as of rice grains was visible over the whole disk, and the faculæ readily traced in all their irregularities. There was no spurious disk such as arises from great atmospheric disturbance, but there was just enough atmospheric tremor to give an occasional *shivering* to the border. There was no disturbance of the limb at the point of first contact.

I was using a Herschel prism solar eye-piece that permitted most of the heat and light rays to pass directly through the eye-tube, whilst the eye-piece was at right angles to the optical axis. The position circle was not constructed to fit this solar eye-piece, and therefore I had to estimate the position on the sun's limb where the moon would first appear. I saw the first indentation when it was about the apparent thickness of a coarse spider thread in the eye-piece, and noted the time, which was, I think, before that of anybody else.

As the moon advanced I noticed the time of disappearance of the umbræ in each of the groups of spots. These were also observed by the others.

As the moon's disk advanced with a well-defined outline apparently broken by lunar mountains, the sun's cusps were very sharp and clear, but whenever a tremor occurred on account of any slight atmospheric disturbance these cusps were apparently doubled. This phenomenon was also observed and recorded by Mr. Colonna. It was not owing to want of parallelism of the colored glasses, for when the atmosphere steadied the cusps were single, sharp points. Had the atmosphere been much more disturbed the points of the cusps would have appeared confused and blunted, as Assistant Rodgers observed them at Oakland. This duplication of the cusp is shown on an exaggerated scale in Fig. 1.

During the progress towards totality I called the observer's attention to the fact that there was a perceptible difference in the darkness of the sky adjacent to the sun's disk yet unobscured, at A, compared with that immediately adjacent and still covered by the moon's advancing disk, which projected beyond the sun's disk at B. And yet none of us had been able to detect the moon's disk before it touched the border of the sun.

At 50 minutes after commencement I noted the "sun much steadier, cusps sharp as knife point, limb of moon sharp."

At one hour after commencement "the limb of the moon steady enough to see the lunar mountains near apparent right cusp" (C), which I was then examining (Fig. 2).

The irregularities of the lunar outline could be detected wherever an examination was made, the more clearly when no shiverings or tremors affected the disk.

Towards totality a few cirrus clouds formed on the line to the sun and the atmospheric disturb.

ances were at times increased. As totality rapidly approached the crescent of sunlight was remarkably long and narrow on account of the slight difference of the apparent diameters of the two disks. To illustrate this I have made the accompanying sketch (Fig. 3) to reduced scale, exhibiting the shape of the crescent at 3 minutes 30 seconds before totality, and at 12 or 13 seconds before the total phase commenced. At the bottom I have exhibited the moon's disk when projected upon the sun about ten seconds after the commencement of the eclipse. The last line of sunlight was from 30° to 40° in length before it broke. But this long, narrow crescent exhibited no distortion from atmospheric disturbances, and no wavy movement, except, occasionally, that slight tremor which I have designated as "shivering," and which is seen at times in geodetic observations. The cusps, before the crescent was reduced to a line, were remarkably sharp and curved points, as if cut by the finest graver. The breaking of this last line of sunlight was occasioned by the intrusion of the lunar mountains and inequalities; and it presented the appearance of a line of dots, dashes, and spaces. There was no wavy motion to interfere with this exhibition; whenever a bright spot or dash disappeared it was gone for good. As in my observations upon similar phenomena in the eclipse of August 7, 1869, the atmospheric conditions were so favorable for steadiness of image that the "Bailey's beads" were totally and wholly wanting.

I did not remove the colored glass in observing this contact, as I had done in 1869, because I wished to preserve my eyes for any possible intra-mercurial planet. But immediately upon leaving the telescope I saw that, on account of the small diameter of the cone of shade, the brightness of the corona, and probably the effect of the light cirrus cloud, the illumined atmosphere rendered the sky too bright to see any stars or small planets, and I fixed in my mind the position and size of the rose-colored flames and especially the first circle of bright light around the sun, whilst others sketched the outline of the corona (Fig. 4).

There was a brilliant rose-colored flame just at the left of the sun's vertex; and the lower part of the moon's disk—say, one-third of the circumference—was apparently bordered by a remarkably brilliant and continuous line of rose-colored flames. The upper flame was between the one-tenth and one-twelfth of the sun's diameter in height; and the lower border of flame was about the one-eighth or one-twentieth of the sun's diameter in height.

The first concentric ring of white light around the sun was strikingly bright and extended one-tenth of the diameter beyond the disk. Mr. Dickins noted this and also a second but fainter concentric ring. The corona had the general form of a parallelogram with the angles prolonged in the direction of the longer sides, and stretched at an angle of about 35° with the vertical, from the upper left to the lower right. The accompanying sketch is a near copy of the sketch which Mr. Colonna and myself made immediately after totality; the parts drawn by Mr. Colonna marked with a C; those by myself with a D. The parts marked (*a*) were much lighter than the other parts of the corona. The outline and general features of the corona are quite consistent among the observers, whilst that of Dr. Gustav Eisen, near Fresno, is equally consistent. In addition to the originals I shall endeavor to have prepared a specially colored sketch.

Two of the observers, Messrs. Colonna and Dickins, distinctly saw the changing appearance of the corona at its most extended points, which seemed to contract and lengthen rapidly; a phenomenon similar to what I observed in the comet of August, 1853.

Messrs. Gilbert and Colonna observed the time of the third contact, although not with confidence.

Before totality we all saw the shadow of the total phase coming over the ocean as a brown area on the surface. After totality I saw the shade of the retreating cone against the eastern sky, but could not see the shadow upon the distant mountains, which were too dark. This shadow had not the density and impressiveness of the shadow coming down the valley of the Chilkaht, Alaska, where it was visible on the flanks of the mountains and against the snow gorges.

After totality the sun was for some time behind a cirro-stratus cloud, and the steadiness of the atmosphere was disturbed. The disk of the sun only came from under this cloud a few minutes before the fourth contact, whilst below the sun lay the cloud bank, which had hung on the horizon all day. This cloud was 35′ above the horizon. Here the atmosphere was in a remarkable state of undulation, and the limbs of the sun and moon moving in great rapid waves, so that it was next to impossible to note in the smaller telescopes precisely when the moon left the sun. I observed it with no satisfaction, except that the time noted was approximately close. The sun set about ten minutes after the last contact.

The following preliminary tabulation will give an idea of the times observed by the different observers. The corrections to the different time-pieces are very close to the truth, but no rigorous reduction has been made.

	Beginning.	End.	Beginning of totality.	End of totality.
	° ′	° ′	° ′	° ′
Predicted ∠ from vertex	−149 32	+14 20	+16 20	−165 15
Observed (approx.) ∠ from vertex	−148 00	+ 7	+20	....
	h. m. s.	h. m. s.	h. m. s.	h. m. s.
Predicted times	2 45 44.9	5 01 10.5	3 56 43.0	3 57 18.4
Observed times: Geo. Davidson	2 45 42.7	5 00 58.7	3 56 37.9	....
J. J. Gilbert	2 45 55.5	5 00 44.0	3 56 34.0	3 57 12.0*
B. A. Colonna	2 45 51.8	5 00 25.7	3 56 41.5	3 57 06.5
E. F. Dickins	2 45 58.2	5 00 38.3	3 56 36.2	....
Geo. F. Davidson	2 45 55.0	5 00 62.0	3 56 45.0	....

* Uncertain.

Equal weight cannot be given to Davidson, jr., as he has not had much experience as an observer.

Incidentally, observations were made for the temperature during the eclipse, but not at regular intervals.

The following are the results, premising that the temperature was 15° at sunrise, with a moderately strong north wind. The wind continued all day, but with decreasing force.

Merc. bar. 2017.	2^h p. m.	$3^h\ 04^m$.	$3^h\ 28^m$.	$3^h\ 43^m$.	Totality $3^h\ 46^m$.	$4^h\ 42^m$.	$5^h\ 01^m$.	$5^h\ 28^m$.
		°	°	°	°	°	°	
Barometer	24^{in}.346	....	....	....	....	....	....	24^{in}.367
Attached thermometer	40°.2	....	....	....	....	....	....	30°.8
Temperature of air	....	28.3	....	31.0	25.0	27.1	28.2	27°.2
Solar radiation	....	67.8	50.8	39.7	28.2	42.4	39.2	....

Jupiter and Mars were seen by the observers several minutes before totality. No stars were seen by any observer.

At Soledad and at Oak Grove the sun was visible at the greatest obscuration; but Señor Villegas informed me that where he was, about 1½ or 2 miles south of Soledad, there was a point of the sun about as bright as Venus, visible about 30° or 40° to the right of the vertex. At Oak Grove, about 1¼ miles south of Soledad, there was a slight line of the sun visible. On the southern limit, at Lowe's stage station, the sun was visible, and at Jolon a very thin line of the sun was visible. I have written to get nearer limits for the southern line of totality. At Fresno, I interested Dr. Gustav Eisen to go to the line of totality where it crosses the Southern Pacific Railroad; and Dr. W. H. Harkness, of the California Academy of Sciences, reports that he went with the party to Sycamore and witnessed the phenomena. The phase of totality was not visible at Fresno on the southern side.

I extract the following description from Dr. Eisen's letter to me:

"The totality was not seen at Fresno; but following your advice I had gone to Borden, a station on the Southern Pacific Railroad about 10 miles north of Fresno. The totality here lasted exactly 31 seconds, and I suppose I was pretty near the central path of the shadow.

"Shortly before totality I suddenly saw the western edge of the moon's surface lighted up by a reddish light, displaying the convex and mountainous surface in a most extraordinary manner. This vanished, however, at totality. The atmosphere seemed perfectly quiet, and no disturbance or tremor of the limbs was visible. At totality the sky around the sun was entirely free from clouds, but so lighted up by the corona, or by something else, that there seemed little prospect of seeing any intra-mercurial planet. The appearance of totality was, to use the faintest language, grand.

"I had my paper prepared according to your instructions, and made a rapid sketch which I inclose herewith. The second accompanying drawing was made after my return home. The red, rosy, and purple flames around the lower left border of the moon, covered, at the beginning of totality, about one-fourth or one-fifth of the border, but increased rapidly, and at the end of totality they covered about one-third of the moon's circumference. Just at the apex I saw an immense pyramidal flame of yellow, very brilliant light, and also a much smaller one at the right horizontal edge, also of brilliant white or yellow light. (Fig. 5, without color.)

"The corona of radiated white, pale light extended from the upper left side to the lower right. * * * The extremities of the corona I could follow to about one diameter distance from the sun. Judging from the shadow of the moon, which we saw passing over the Sierra, the diameter of cone could not have been much more than ten miles."

Dr. Harkness informed me that the shadow was very distinct because the Sierra was covered with snow, and that it passed like the shadow of a cloud.

I. P. Moore, esq. (vice-president of the California Academy of Sciences), observing the eclipse at San Rafael, reports that at commencement he saw iridescent colors at the part of the sun first touched by the moon, but that they immediately disappeared.

As a spectacle, this eclipse in some respects exceeded, and in others was inferior to, that which I observed August 7, 1869, in Alaska. Here the rose-colored flames and inner circle of white light were perfectly glorious, and the corona was more brilliant, but the disk of the moon did not stand out with that blackness and perspective effect which I saw on the Chilkaht. This might be in part the result of interference by the cirrus clouds. The sky here was much brighter on account of the closeness of the apparent diameters of the sun and moon. The shadow on the ocean was a poorly defined brown area; in the valley of the Chilkaht the coming of the shadow on the mountain flanks and over the snow gorges was more distinct. Near Fresno and at Millerton the shadow was seen coming over the San Joaquin plains, and after totality the shadow was very beautifully distinct on the snow-covered flanks of the Sierra Nevada.

This eclipse affords another confirmation of the theory which I have before reported, that the exhibition of "Baily's Beads," the "ligament" and "black drop" in transits of Mercury and Venus, the projection of a colored star on the moon's bright limb at occultation, and similar phenomena, are the consequences of atmospheric disturbances occasioned by irregularities of refraction, etc., which create spurious disks of the sun, moon, and planets. This view, when first insisted upon, was strongly controverted, but we have analogous phenomena exhibited almost every day in the geodetic observations of the Survey. At high isolated elevations, and during a remarkably steady atmosphere, whether dry or moist, at any elevation, all these abnormal conditions vanish.

I may mention here, that whilst at this station the zodiacal light was observed every evening when the weather was clear. It was distinctly marked, and stretched up to an elevation from 4° to 6° higher than Jupiter, and from 4° to 5° to the right. The base, at 6½ or 7 p. m., was about 12° broad, and the inclination 10° from the vertical to the left.

I inclose special reports of Assistants Gilbert and Colonna and Subassistant Dickins, with their sketches; also second sketch of Dr. Eisen (Fig. 5).

The original records for time, latitude, and the epochs of commencement, etc., together with the original sketches, will be duly transmitted.

Yours respectfully,

GEORGE DAVIDSON,
Assistant Coast and Geodetic Survey.

CARLILE P. PATTERSON,
Superintendent Coast and Geodetic Survey.

JANUARY 29, 1880.

P. S.—Assistant Colonna has reduced two pairs of the latitude stars, which give the latitude of the station 36° 08′ 40″, and I have graphically located the station from Mr. Dickins's horizontal directions and Mr. Eimbeck's positions on his reconnaissance plan of 1873. This gives for the longitude 121° 23′ 40″, to which must be added 1′ 02″ for determination by telegraph longitudes, so that we may provisionally place

Station Santa Lucia in latitude 36° 08′ 40″; longitude 121° 24′ 40″.

A closer approximation to the longitude could doubtless be made by computing the triangles of the reconnaissance from Mr. Eimbeck's measures. G. D.

Fig. 1

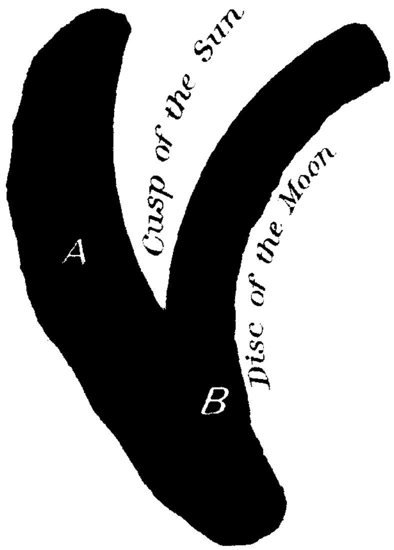


Fig. 2

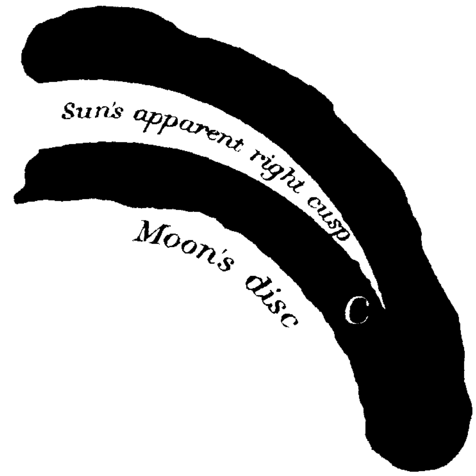


Fig. 3

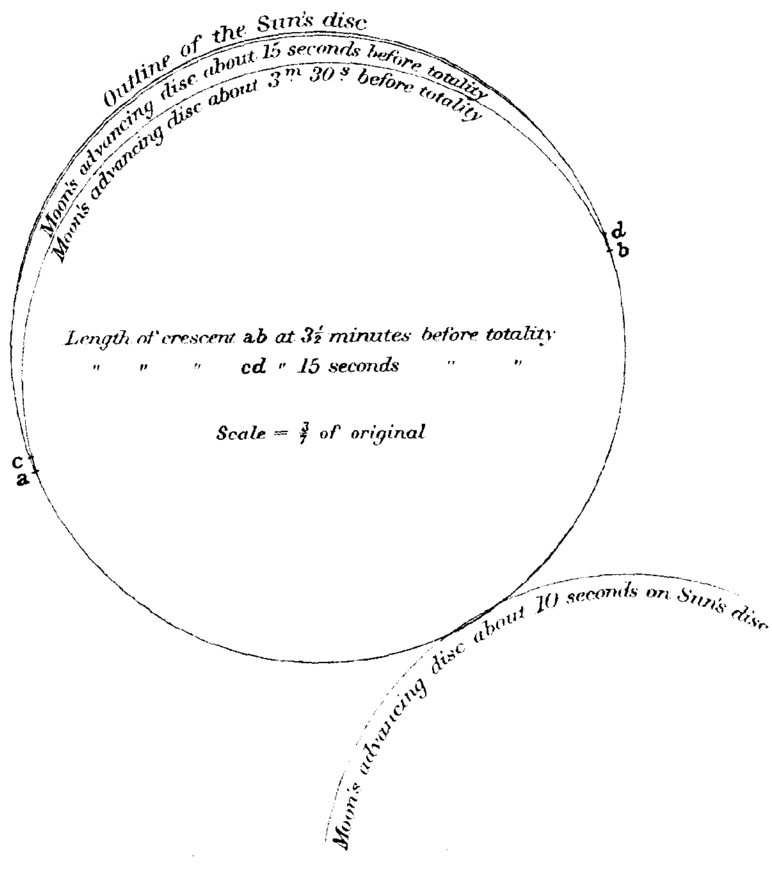


Fig. 4

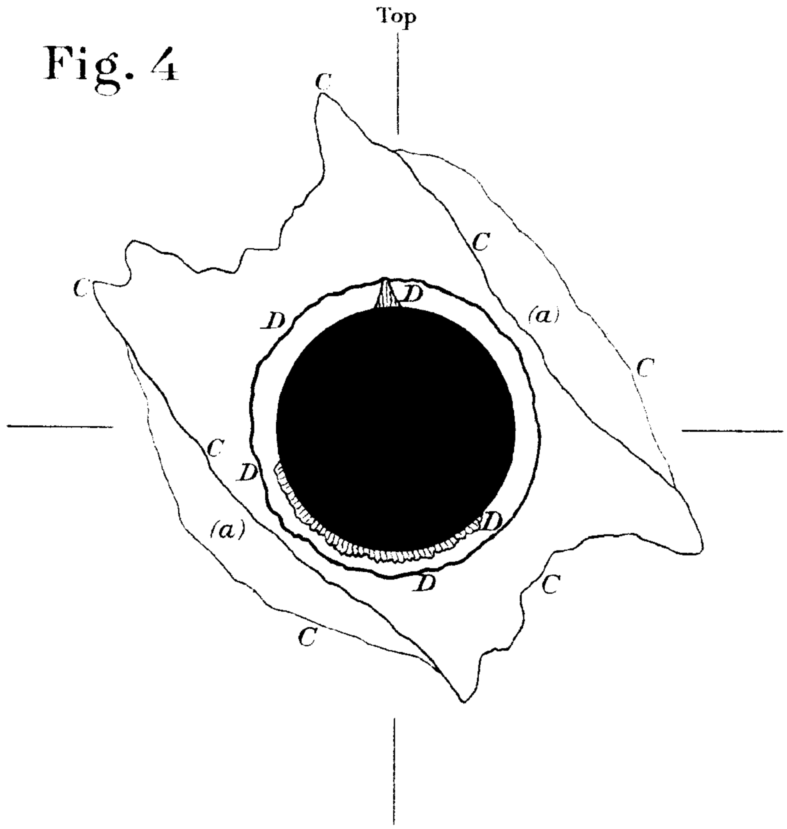
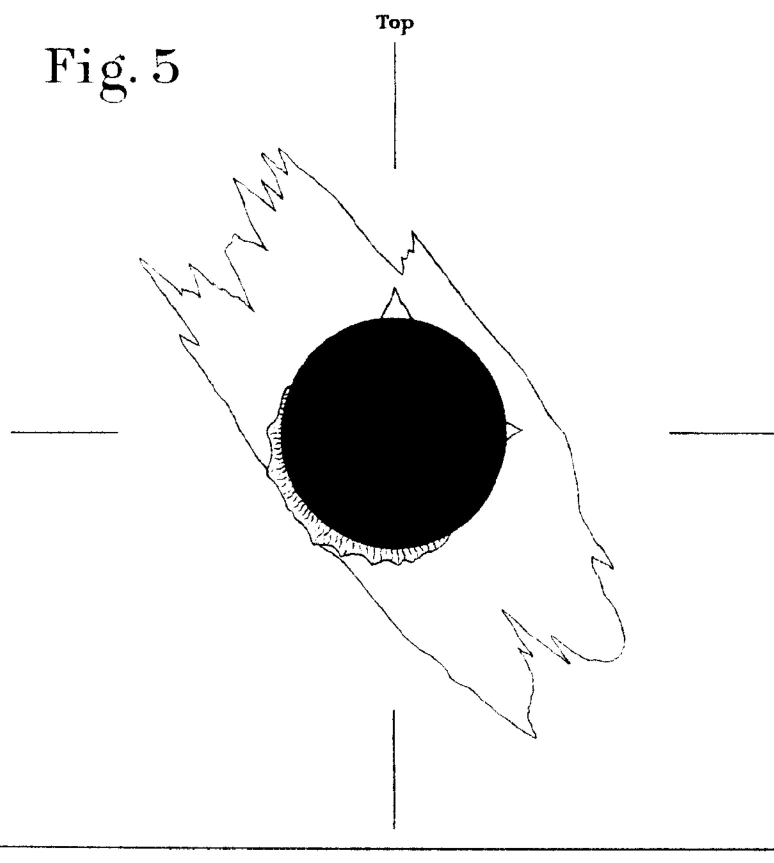


Fig. 5



Note to Appendix No. 21.

(COAST AND GEODETIC SURVEY REPORT FOR 1882.)

In preparing the "New Reduction of La Caille's Observations of Fundamental Stars in the Southern Heavens," for publication in the Coast Survey Report, the statement was inadvertently omitted that the reduction was undertaken by Dr. Powalky at the charge of the "Bache Fund of the National Academy of Sciences."

This fund was bequeathed by Alexander Dallas Bache, late superintendent of the Coast Survey, for purposes of scientific research. The board of direction which sanctioned the present investigation consisted of Professors Benjamin Peirce, Joseph Henry, and James D. Dana.

While this paper will be published as a part of the "Bache Fund Memoirs," it was deemed desirable, in view of its importance to astronomical science, to give it the wide publication afforded by the Coast Survey Report.

J. E. HILGARD,
Superintendent U. S. Coast and Geodetic Survey.

October, 1883.

APPENDIX No. 21.

A NEW REDUCTION OF LA CAILLE'S OBSERVATIONS, MADE AT THE CAPE OF GOOD HOPE AND AT PARIS BETWEEN 1749 AND 1757, AND GIVEN IN HIS "ASTRONOMIÆ FUNDAMENTA," TOGETHER WITH A COMPARISON OF THE RESULTS WITH THE BRADLEY-BESSEL "FUNDAMENTA;" ALSO A CATALOGUE OF THE PLACES OF 150 STARS SOUTH OF DECLINATION —30°, FOR THE EPOCHS 1750 AND 1830.

By C. R. POWALKY, Ph. D.

PREFACE.

In order to determine the proper motion of stars, a comparison of modern places with older ones is necessary. Bradley's observations, reduced by Bessel to the mean epoch 1755.0, have principally been used up to this time for the proper motions of northern stars. At the instance of the director of the observatory at Pulkowa, and with the approval of the Russian Government, Dr. Auwers has now undertaken a new reduction of these observations, and the publication of the results may shortly be expected. Johnson's Catalogue for 1830 of St. Helena has heretofore served for southern stars south of declination —30°, excepting for a few stars observed by Piazzi up to —45° and reduced in his catalogue for 1800.0; there are also available the few but excellent observations made at the Cape in 1833 by Henderson, and the observations made (about 1840) at Madras by Taylor, which reach to declination —70°; finally, we have La Caille's observations at the Cape, as reduced by himself to 1750.0.

Up to the present time no thorough revision has appeared, although the inaccuracy of La Caille's reduction and the utter unreliability of the observations have been pointed out in the "Viertel-Jahrschrift" of the Astronomical Association, and by Stone in the latest observations at the Cape. In 1845 the British Association published a catalogue of La Caille's observations of nearly 10,000 stars; the reduction was undertaken by Henderson, but was never completed by him; besides, there was no account taken, in the fundamental determinations, of the errors introduced by La Caille, and there was added a not inconsiderable number of new ones, as shown by Argelander in "Investigation of the proper motion of 250 stars," vol. 7 of the Observations at Bonn, pp. 6, 7.

In judging of the value of La Caille's observations, we have to distinguish carefully between his "Astronomiæ Fundamenta," and his "Micrometrical Observations." The former are almost of equal accuracy with those of Bradley, as shown in my comparison of the newly reduced northern stars (in Table I for the right ascension, and in Table II for the declinations).

On the other hand, the micrometric observations are certainly of very much less value, since each star place depends only on two transits over threads, recorded to the nearest whole second, and in these observations many errors occur, especially in cases when many stars follow one another at short intervals. Nevertheless, a new discussion of the whole material might not be without value, although we cannot place implicit confidence in his micrometric observations.

The observations of the "Astronomiæ Fundamenta," upon the whole, have reference only to 400 stars, and in my opinion the declinations of the *northern* stars can no longer be disregarded, but deserve to be placed side by side with those of Bradley. For their combination, however, to form a most probable result, I need more accurate information than is now in my possession.

For the southern stars, south of declination —30°, we have no better material for the determination of the proper motions, or of a possible variability during the long interval of 125 years intervening between La Caille and Gould (for 1875).

INTRODUCTION.

My object in undertaking this work was to bring to a clearer understanding the value of La Caille's observations as a supplement to the Bradley-Bessel results.

I am fully aware that an intended revision of Bradley's observations will establish a newer and probably a better basis for the reduction of astronomical observations; it will, nevertheless, be an easy task to apply afterwards the necessary small corrections to my results, since those changes, not being very large, will certainly not act in opposition to the purpose I have in view.

La Caille's determinations of right ascension at Paris by the method of equal altitudes I have entirely omitted, they having but little value in comparison with Bradley's numerous transits, on account of the lesser inclination of the horizon to the equator. But this does not apply to southern stars at the Cape, whose right ascensions were determined by the same method by La Caille, of which only a few were observed by Bradley, with his transit, at Greenwich (see "Table I, A. R. app.—Culm.").

The small number of observed zenith distances at Klipfonteyn and Isle de France, I have likewise at first omitted.

That the determinations of right ascensions and declinations of stars resulting from my revision, may have lost part of their former absoluteness by being now founded on the total number of Bradley synchronous observations, could hardly be considered a disadvantage of the revision, as the polar point deduced from La Caille's observations of upper and lower culminations of Polaris agrees very nearly with Bradley's, while the equinoctial point (the initial point of longitude and latitude), from observations of La Caille (the sun's southern limb was observed at the Cape only near both equinoxes), could not be determined with sufficient accuracy.

In consequence of the large number of comparisons of declinations with Bessel's results of Bradley's observations, the hitherto undetermined errors of division of Bradley's mural quadrant and La Caille's sector and sextant have been nearly eliminated.

La Caille used at the Cape, for the observations of equal altitudes, an iron 3-foot quadrant in connection with a 3½-foot telescope and a clock of Le Roy. The comparison of clock corrections in Table I proves clearly the superiority of the instruments as well as La Caille's ability in using them.

Each of La Caille's observed altitudes was taken on two parallel threads. The column in Table I, headed "Culm. Clock-time," contains the mean of La Caille's observed clock times, corrected for the influence of the changes of temperature, and in case of the sun for the equation of equal altitudes. The differences of temperature were taken from a table (Dove) of the mean daily temperature for the Cape.

La Caille gave the times only to half seconds, and, although the mean error in the *mean* of the culmination times generally amounts to more than $0^s.1$, I have retained the hundredths in the reduction, so that this error should not be increased by the neglect of the second decimal. Column Z contains the number of sets of observed equal altitudes. Under the heading "A. R. app.—Culm.," followed by a column containing capital letters (the initial of the authority), is shown the difference of apparent right ascension and the observed culmination time, computed according to the respective authors. "H. O." indicates Hansen-Olafsen's solar tables; "A.," Auwers; "F.," Bessel's Fundamenta; and "T. R.," Bessel's Tabulæ Regiomontanæ. From this column were deduced the clock correction and its hourly rate, also the corrections for apparent right ascensions of stars where no authority is found. The last column, headed "La Caille—N," shows the difference between the old and my new reduction of the observed right ascensions.

The zenith distances given in La Caille's Fundamenta (pp. 161–209) for Paris (place of observation: Collége Mazarin) and at the Cape, "Distantia observata," are the results of direct measurements with a 6-foot sector and a 6-foot sextant, corrected for zenith point and errors of division of the arc. The least recorded errors of division amount to $3''.3$; for the sextant they were found worthy of mention only on three points: by Canopus ($3''.3$) and by ν Doradus and ω Argus ($5''.0$).

The sector, which comprised 51°, read, according to La Caille, in the zenith at Collége Mazarin (Paris), 26° 23′ 7″.6; at Cape Town (Cape), 26° 23′ 10″.0; at Klipfonteyn, 26° 23′ 1″.0.

Every star had been observed during several days three, four, or more times with the circle east, and as out as many times with circle west (hence direct and reversed), and every observation is given in this manner.

At Paris the sector was connected on the left edge with another 5-foot telescope, provided with a micrometer. With this telescope zenith distances could be observed from 0° to 50°.

The sextant of similar contrivance, comprising 64°, and provided at the Cape with a smaller telescope (5-foot), perpendicular to the principal telescope (6-foot), was put in such a position that all zenith distances could be observed, either with one or the other telescope. Small weight is given by La Caille to those made with the smaller telescope, on account of the lesser power. For stars at low altitudes the refraction without special notice of temperature becomes somewhat uncertain; for southern stars, however, zenith distances are observed with the smaller telescope down to 67° 23′ (β Hydri S. P.), and in general only for a few stars.

The zenith point of the sextant, the divisions of which extended several degrees beyond the zenith, was determined by reversing the instrument in the same way as with the sector at the Cape, as well as at Paris, by stars near the zenith. In Tables II, II_a, and IV the names of these stars are underlined.

To the zenith distances given by La Caille for the different dates under "Distantia observata," I have applied the reduction to the mean place of 1750.0* and the refraction corrected for mean temperature (from Dove's tables) and barometer.†

For the observation with the principal telescopes of the sector and of the sextant, near the zenith in two directions of the circle, I have taken the mean of the means of the zenith distances for every star, observed east and west, corrected for refraction and reduced to the mean place of 1750.0, and for the remainder only the single means were retained. The probable errors of the single means are generally less than 1″; the differences, however, resulting from the means of the readings on the sector towards both sides, according to La Caille's statements (to the immediate readings La Caille applied the zenith point correction), are generally greater, and amount in some cases from 6″ to 8″; these I have marked with (:); for two northern stars, where they amount to 10″ with (::); and isolated corrections with (Γ). The column in La Caille's Fundamenta, following that of "Distantia observata," contains his zenith distances corrected only for the reduction to mean place and not for refraction, and a comparison with my computation enabled me to find discrepancies of from 1″ to 2″, besides some greater ones, as in case of ι Lupi and α Doradus. This comparison, therefore, protected me from greater errors. More considerable, however, are the differences arising from refraction and assumed latitude. The Pulkowa tables, agreeing best with the more recent determinations, give for the refraction, at 45° zenith distance, $57''.9 \pm i$ (i=correction for barometer and temperature), whilst La Caille, without regard to change of barometer and temperature, assumed for Paris 66″.5, and for the Cape 64″.9 (compare the table of refraction in La Caille's Fundamenta, p. 214).

La Caille assumed his latitude at Paris to be +48° 51′ 29″.2, and that of the Cape —33″ 55′ 13″.3. For the place of La Caille's observations at Paris, I used that given to me by the late Admiral Davis, +48° 51′ 25″.6. For the latitude of the Cape, I used —33° 55′ 15″.8, which value is derived from La Caille's newly reduced observations of upper and lower culminations with the sextant, from 4 stars with the principal and from 2 stars with the smaller telescope, giving the former double weight of the latter.

Maclear, in 1839, found for La Caille's place of observation — 33° 55′ 16″.1, a difference of only 0″.3, which is of small importance.

In Tables II to IV_b, inclusive, are grouped the declinations (arranging them from north to south and with regard to instrument and place of observation) resulting from zenith distances, corrected for refraction and my assumed latitude, and reduced to the mean place of 1750.0.

The heading gives the name of the instrument, place of observation, and a formula for the sum of the corrections.

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* The constants of the day for 1749 were taken from the "Tafeln zur Reduction von Fixsternbeobachtungen für 1726–1750. Zweites Supplementheft der astrom. Gesell., 1869"; for 1750–1757 from the "Tabulæ Quantitatum Besselianarum pro annis 1750–1840, von O. Struve, Petersburg, 1869" and the reduction computed for every ten days and interpolated for the intermediate days.

† Tabulæ Refractionum in usum Speculæ Pulcovensis congestæ, Petropoli, 1870.

The first column contains the name of the star, the following, the mean of the times of observations, the third the mean declinations for 1750.0, without proper motion; then follows the comparison with Bessel's declinations, given in his Fundamenta (=Bessel ±), and finally the correction (derived from the above formula) to the mean declinations as given in the main column. I have not given the number of observations, but have marked isolated observations (┌┐ before the result). Those so designated show but inferior discordances from other results of La Caille or Bessel. Two northern stars, α and ε Cygni, are observed but twice, the remainder, however, with few exceptions, five and more times (the unknown errors of division are decidedly larger than the probable errors of observation).

As La Caille discovered a change in the reading of the zenith point in 1756, April 21, and in consequence thereof I assumed a change in the eccentricity, those mean declinations resulting from the zenith distances observed with the sextant at Paris are given separately in Tables II and II_a, retaining in this case also the number of observations; Table V contains the united results of those observations with regard to the number of observations. During observations at the Cape La Caille records also a change in the index correction of the sextant (using the smaller telescope), for which he found it sufficient to apply a constant correction, which I have retained unaltered. With these two exceptions the positions of the instruments at one and the same place were assumed to have remained the same during the entire time of observation.

A comparison of the old and new declinations in Tables II to IV_b, inclusive, shows by the sum of the declinations, obtained from upper and lower culminations of Polaris, that each result requires a correction nearly equal in magnitude and sign to the difference of La Caille's and Bradley's determinations. According to a comparison of Tables II and II_a with Bradley-Bessel, all declination observed with the sextant at Paris require for stars north of the zenith a positive, and south a negative correction, generally increasing from north towards south.

The sextant observations at the Cape show that the declinations in Table IV require in general positive corrections from 27° to −10° of declination and negative corrections for stars observed in both culminations.

According to the comparison with Bessel in Tables III and III_a for the sector at Paris, the declinations require nearly equal corrections, as obtained from the sextant, only somewhat larger for greater zenith distances both north and south.

At the Cape the observations with the sector and sextant placed the stars north of the zenith less north, and stars south of the zenith less south.

Those discrepancies just mentioned are in general far greater than can be attributed solely to errors of observation and errors of division, but they may be assumed to arise from the uncertainty in the correction for eccentricity, and perhaps also from flexure of the circle, and of the telescope. All, however, become eliminated by the determination of x and y in $x \sin \delta + y \cos \delta$ from the observations, so that they agree among themselves almost within the unavoidable errors of observation.

Assuming that Bessel in his reduction of Bradley's observations obtained these final results very approximately, I have determined by the method of least squares (introducing weights, according to the number of comparisons) the coefficients x and y from all the comparisons (Bradley-Bessel) in Tables II to IV_b separately for the different sets of observations at Paris and at the Cape; at the place last mentioned, I have also introduced 4 circumpolar stars observed in both culminations with the principal telescope of the sextant, for a more accurate determination of the sine coefficient. La Caille's observations at the Cape with the smaller telescope of the sextant comprise an arc of 154°; the comparisons with Bessel I could unite into two groups, and a third I obtained from the stars near the south pole, by the comparisons given in Table IV_a under "*P*" with the corrected results obtained from the sextant (using the principal telescope). After the solution of the normal equations the results of the three groups agreed very well.

The observations with the sector at the Cape comprise an arc of only 46°, and comparisons with Bessel can only be made for stars observed north of the zenith at the Cape; south of the zenith I had only two comparisons with the corrected results of the sextant at the Cape, which are those of Canopus and ζ Aræ. The observations of Canopus, made with both instruments, are quite numerous; for the sector, the reduced zenith distances, taken east and west, agree; and those for the sextant are corrected for a division error by La Caille. After the application of the corrections the declinations of these two stars with both instruments agree very well, and lie near the southern limit of the arc of the sector. In fact both limits seem to be well determined.

The more frequent and greater discordances between La Caille and Bradley, near the zenith at the Cape and near the horizon at Greenwich, are probably due to the uncertainty of Bessel-Bradley's position.

Table V is a recapitulation of declinations of stars finally reduced from Tables II to IV_b, inclusive.

In the heading are found the name of the instrument and the place of observation by the following designations: C_p, $C_{p\prime}$, and C_c for the result of the sector observations at Paris and at the Cape, respectively (accented letters refer to the small telescope of the sector, and unaccented to the principal), and by X similarly for the sextant. The declination is only given complete in the first column following the name of the star, and in following columns only the seconds of arc are retained. Under the heading (α) are found the right ascensions in arc, to the nearest minute, for an easy identification. Then follows under "Bradley" Bessel's declinations for 1750.0 of Bradley's observations, taken from the catalogue of Bessel's Fundamenta; next, under "La Caille," the mean value of the declination as deduced with the different instruments at Paris and at the Cape. (Results obtained from an average number of observations with the principal telescope have the weight 2, and isolated observations with the principal telescope, or any number with the smaller telescope, the weight 1; I have taken this as a general rule, although I would have decided differently in some instances.) The next column gives the magnitude of the stars, taken from La Caille's catalogue; then the mean year of observations with regard to weights; and the last column contains the sum of the weights according to the above rule.

Table VI, the catalogue of southern stars from $-30°$ of declination to the south pole, is arranged according to right ascension, and given for 1750.0 as well as for 1830.0, using Bessel's constants of precession, without regard to proper motion. For the catalogue referred to 1750.0 I have given the corrections to be applied to La Caille's catalogue, and for 1830.0 the difference Johnson La Caille. The catalogue for 1830.0 may also serve for a comparison with the catalogues of Henderson (few but accurate positions, and near that epoch), Brisbane, Rumker (these reductions, I regret, are not now at my disposal), and also with Taylor and Maclear.

Even a new reduction of Bradley's observations would not materially alter the present fundamental catalogue for 1750, and therefore this catalogue may serve for a basis of a new reduction of La Caille's micrometric measurements of numerous stars contained in "Cœlum australe stelliferum."

For illustration I have added a few examples of my reduction of sextant and sector observations, together with La Caille's computation. I have to remark, according to my reduction, the uncommonly large errors of observation and the difference between the results derived from morning and evening observations with the sextant at the Cape, by the series of α Virginis, given here in the examples. However, the sector observations of this star agree satisfactorily.

Examples.

1. SEXTANT AT PARIS.

POLARIS IN CULM. SUPER (AT UPPER CULMINATION).

Tempus observationis.	Distantia observata.	Reduct. ad 1750.1.	Refract.	Distantia med. pro 1750.0.
1755.	° ′ ″	″	″	° ′ ″
July 31	39 7 11.0	− 90.0	+ 46.4	39 6 27.4
Aug. 10	13.9	− 92.4	46.4	27.9
21	18.2	− 95.5	46.3	29.0
22	15.1	− 95.8	46.3	25.6
23	18.3	− 96.1	46.3	28.5
Nov. 14	43.2	−125.7	47.8	25.3
15	42.7	−126.0	47.8	24.5
20	43.8	−127.5	47.8	24.1
Dec. 17	49.2	−133.5	48.2	23.9
18	49.2	−133.7	48.2	23.7
20	49.2	−134.0	48.2	23.4
21	55.8	−134.1	48.2	29.9
29	53.1	−134.9	48.3	26.5
30	56.2	−135.0	48.3	29.5
1756.				
Jan. 13	58.7	−135.3	48.3	31.7
16	58.4	−135.2	48.3	31.5
22	60.3	−134.9	48.2	33.6
July 29	31.2	−107.4	46.4	30.2
31	30.8	−107.0	46.4	29.4
Aug. 30	31.9	−116.3	46.4	22.0
31	34.4	−116.6	46.4	24.2
Mean				39 6 27.4
Latitude				48 51 25.6
				87 57 53.0
Corr				+ 10.0
Declination				87 58 3.0

POLARIS IN CULM. INFER (AT LOWER CULMINATION).

Tempus observationis.	Distantia observata.	Reduct. ad 1750.0.	Refract.	Distantia med. 1750.0.
1755.	° ′ ″	″	″	° ′ ″
May 25	43 8 0.1	+ 86.9	+ 53.4	43 10 20.4
26	0.5	+ 86.7	53.3	20.5
27	0.5	+ 86.6	53.3	20.4
28	7 59.4	+ 86.5	53.3	19.2
29	59.4	+ 86.4	53.3	19.1
30	8 1.8	+ 86.3	53.2	21.3
Dec. 21	7 8.8	+134.2	55.8	18.8
30	9.3	+134.9	55.8	20.0
31	13.9	+135.0	55.8	24.7
1756.				
Jan. 3	14.0	+135.0	55.9	24.9
7	14.7	+135.3	55.9	25.9
17	11.9	+135.1	55.9	22.9
June 5	42.3	+103.3	53.0	18.6
6	41.0	+103.3	53.0	17.3
10	44.0	+103.1	52.8	19.9
11	42.6	+103.0	52.8	18.4
Mean				43 10 20.8
Latitude				48 51 25.6
				92 1 46.4
				+ 10.7
Declination				92 1 57.1

La Caille's computation was:

		° ′ ″
(Culm. sup.)	Distantia reducta..	39 5 39.7
	Refract. (pag. 214).	+ 54.0
		39 6 33.7
	Latitude	48 51 29.2
	Declination	87 58 2.9

		° ′ ″
(Culm. inf.)	Distantia reducta..	43 9 26.9
	Refract	+ 1 2.4
		43 10 29.3
	Latitude	48 51 29.2
	Declination	92 1 58.5

2. α VIRGINIS.

a SEXTANT AT PARIS.

Tempus observationis.	Distantia observata.	Reduct. ad 1750.0.	Refract.	Distantia med. 1750.0.
1756.	° ′ ″	″	″	° ′ ″
May 21	58 42 30.2	−122.4	+ 93.1	58 41 60.9
25	33.3	−122.3	93.1	64.1
28	30.9	−122.2	93.1	61.8
30	30.9	−122.1	93.1	61.9
31	34.9	−122.1	93.1	65.9
Dec. 12	23.5	−121.9	96.9	58.5
13	21.2	−122.1	96.9	55.9
14	31.2	−122.3	96.9	65.8
17	27.7	−122.8	96.9	61.8
22	30.5	−123.7	97.0	63.8
23	25.6	−123.9	97.0	58.7
Mean				58 42 1.7
Latitude				48 51 25.6
				− 9 50 36.1
Corr'n				− 13.7
M. declin'n				− 9 50 49.8

b SEXTANT AT THE CAPE.

Tempus observationis.	Distantia observata.	Reduct. ad 1750.0.	Refract.	Distantia med. 1750.0.
1752.	° ′ ″	″	″	° ′ ″
Jan. 8	24 3 10.8	+ 42.1	+ 25.3	24 4 18.2
27	5.6	+ 45.0	25.3	16.0
28	6.3	+ 45.2	25.4	16.9
29	4.6	+ 45.4	25.4	15.4
Feb. 3	3.5	+ 46.3	25.4	15.2
July 23	9.1	+ 51.7	25.8	26.6
25	9.7	+ 51.6	25.8	27.1
26	8.6	+ 51.5	25.8	25.9
31	8.0	+ 51.1	25.8	24.9
Aug. 1	1.8	+ 51.0	25.7	18.6
6	5.6	+ 50.7	25.7	22.0
8	9.7	+ 50.6	25.7	26.0
Mean				24 4 21.1
Latitude				− 33 55 15.8
				− 9 50 54.7
Corr'n				+ 2.1
M. declin'n				− 9 50 52.6

c SECTOR AT THE CAPE.

Tempus observationis.	Distantia observata.	Reduct. ad 1750.0.	Refract.	Distantia med. 1750.0.	
1751.	° ′ ″	″	″	° ′ ″	
June 5	24 3 14.1	+ 37.3	+ 25.8	24 4 17.2	In parte dextera.
9	12.8	+ 37.2	25.9	15.9	
12	15.8	+ 37.0	25.8	18.6	
28	18.0	+ 36.2	25.9	20.1	
30	15.5	+ 36.1	25.8	17.4	
July 4	17.5	+ 35.8	25.8	19.1	
21	17.6	+ 34.7	25.7	18.0	
1752.					
Jan. 22	2.8	+ 45.0	25.4	13.2	
1751.					
June 13	11.7	+ 37.0	25.8	14.5	In parte sinistra.
July 14	19.7	+ 35.2	25.9	20.8	
16	17.7	+ 35.1	25.8	18.6	
17	17.3	+ 35.0	25.9	18.2	
22	17.6	+ 34.6	25.8	18.0	
23	18.3	+ 34.5	25.8	18.6	
Mean				24 4 17.7	
Latitude				−33 55 15.8	
				− 9 50 58.1	
Corr'n				+ 7.8	
M. declin'n				− 9 50 50.3	

BY LACAILLE'S COMPUTATION.

	Sextant (Paris).	Sextant (Cape).	Sector (Cape).
	° ′ ″	° ′ ″	° ′ ″
Dist. red	58 40 26.2	24 3 55.6	24 3 52.
Refract	+ 1 48.6	+ 29.1	+ 29.1
	58 42 14.8	24 4 24.7	24 4 21.2
Latitude	48 51 29.2	−33 55 13.3	− 33 55 13.3
	− 9 50 45.6	− 9 50 48.6	− 9 50 52.3

Catalogue (Fundam. p. 235) − 9 50 50.4

I conclude with a table giving a comparison of my reduced apparent declinations of the sun with Hansen-Olufsen's solar tables. (The observed apparent zenith distances are found on page 241 of the "Astronomiae Fundamenta.")

Dates.	☉'s limb.	Compar. C.—O.	Dates.	☉'s limb.	Compar. C.—O.	Dates.	☉'s limb.	Compar. C.—O.	Dates.	☉'s limb.	Compar. C.—O.
1751.		"	1751.		"	1752.		"	1752.		"
Sept. 1	S.	+ 4.0	Nov. 5	S.	+ 1.2	Feb. 9	S.	− 3.6	June 20	S.	− 1.3
2	N.	−16.7	8	N.	− 4.8	Mar. 3	S.	− 2.2	22	S.	+ 0.9
3	S.	+ 3.3	Dec. 19	S.	+ 9.4	4	S.	− 5.6	24	S.	+ 3.9
13	S.	+ 4.6	20	S.	+ 6.1	5	S.	− 7.4	25	S.	+ 1.8
14	S.	+ 3.4	21	S.	+ 7.5	7	S.	− 0.4	Aug. 31	S.	+ 1.2
15	S.	+ 2.0	22	S.	+ 7.2	12	S.	− 0.6	Sept. 1	N.	−12.7
29	S.	+ 4.2	24	S.	+ 6.4	13	S.	− 2.5	Dec. 16	S.	+ 5.6
30	S.	+ 8.7	25	S.	+ 3.0	14	S.	− 2.6	17	S.	+ 4.3
Oct. 1	S.	+11.0	26	S.	+ 7.1	28	S.	+ 1.7	18	S.	+ 8.2
2	S.	+ 7.2	27	S.	+ 7.3	30	S.	+ 3.0	19	S.	+11.7
3	S.	+ 3.9				Apr. 1	S.	− 1.0	20	S.	+10.9
4	S.	− 1.7	1752.			June 15	S.	+ 2.7	21	S.	+10.8
6	S.	+10.1	Feb. 3	N.	−10.1	16	S.	− 1.9	22	S.	+ 9.3
7	S.	+ 0.3	4	S.	+ 0.4	17	S.	+ 2.6	23	S.	+ 9.5
8	S.	− 4.0	6	S.	+ 3.7	18	S.	− 4.0	25	S.	+ 3.1
9	S.	− 0.1	8	S.	− 2.9	19	S.	+ 0.5	26	S.	+ 5.6

Not corrected for eccentricity.

I.—*Right Ascensions.*

1751, May 25. At Clock-time $15^h\ 58^m$: Corr'n$=+5^s.37+0^s.868$ h.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	LaC. —N.
	h. m. s.		s.		s.	h. m. s.	s.
☉	4 7 4.10	3	− 4.61	H. O.			
ι Centauri	13 6 39.87	1	+ 4.9	$\overset{27}{\text{v}}$ 51	(− 6.91)		
β Centauri	13 46 32.40	6	+ 3.80	$\overset{30}{\text{III}}$ 52	(− 9.28)		
α Lupi	14 25 31.76	7	+ 4.03	....	− 8.52	14 25 27.27	0.0
α² Centauri	14 22 56.66	3	+ 3.35	$\overset{31}{\text{v}}$ 51	(−10.11)		
β Tria. a.	15 33 29.80	6	+ 5.01	....	−11.86	15 33 22.95	0.0
Antares	16 14 9.99	6	+ 5.18	T. R.			
η Ophiuchi	16 56 5.04	5	+ 6.08	F.			
δ Sagitt	18 4 59.29	7	+ 8.22	F.			
ι Scorpii	17 30 10.16	7	+ 6.68	....	− 8.85	17 30 7.99	−0.17

1751, May 26.

☉	4 10 46.37	3	+ 15.54	H. O.			

1751, May 27. Clock-timr, $15^h\ 0^m$: Corr'n$=+17^s.15-0^s.181$ h.

ι Centauri	13 6 27.32	8	+ 17.49	....	− 6.90	13 6 37.91	+0.20
γ Hydræ	13 5 12.21	8	+ 17.47	F.			
Spica	13 11 52.39	8	+ 17.36	T. R.			
η Centauri	14 19 35.49	7	+ 17.27	....	− 8.05	14 19 44.71	+0.10
λ Virginis	14 5 26.67	7	+ 17.36	F.			
γ Scorpii	14 49 20.17	6	+ 17.18	F.			
α² Libræ	14 36 55.29	9	+ 17.37	T. R.			
γ Libræ	15 21 24.90	7	+ 17.14	F.			
ν Scorpii	17 13 39.81	6	+ 16.75	....	− 8.65	17 13 47.91	+0.22
θ Ophiuchi	17 6 31.81	6	+ 16.85	F.			
γ Sagitt, seq	17 49 36.89	7	+ 16.45	F.			
—— præc	17 48 54.98	7	+ 16.64	....	− 8.02	17 49 3.60	+0.11

I.—*Right Ascensions*—Continued.

1751, MAY 30. AT CLOCK-TIME $16^h 30^m$: CORR'N $= +3^s.63 - 0^s.210$ h.

	Nomen.	Culmin. Clock-time.	Num.	A. R. app. −Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	LaC. −N.
		h. m. s.		s.		s.	h. m. s.	s.
	Sirius	6 34 5.66	8	+ 5.62	A.			
	Spica	13 12 5.66	7	+ 4.07	T. R.			
ε	Centaur	13 24 17.87	7	+ 4.28	....	− 8.04	13 24 14.11	+0.38
θ	Centaur	13 52 7.13	7	+ 4.18	....	− 7.39	13 52 3.92	+0.38
ζ	Centaur	13 40 8.75	6	+ 4.24	....	− 7.86	13 40 5.13	+0.26
δ	Lupi	15 5 8.23	8	+ 3.93	....	− 8.39	15 5 3.77	+0.36
γ	Tria. a	14 56 9.04	7	+ 3.96	....	−12.75	14 56 0.25	+0.41
π	Scorpii	15 43 50.60	8	+ 3.99	F.			
ε	Lupi	15 5 54.18	7	+ 3.92	....	− 8.71	15 5 49.39	+0.32
	Antares	16 14 11.50	9	+ 3.73	T. R.			
β	Scorpii	15 51 0.08	8	+ 3.87	F.			
γ	Ophiuchi	17 35 25.27	6	+ 3.50	F.			
ε	Sagitt	18 7 39.90	6	+ 3.29	....	− 8.35	18 7 34.84	+0.27
λ	Sagitt	18 12 36.95	8	+ 3.24	F.			
η	Sagitt	18 0 48.04	6	+ 3.32	....	− 8.57	18 0 42.79	+0.28

1751, MAY 31. AT $13^h 56^m$: CORR'N $= -0^s.935 - 0.1974$ h.

	☉	4 31 19.88	7	+ 1.04	H. O.			
	Sirius	6 34 10.73	9	+ 0.55	A.			
	Spica	13 12 10.67	8	− 0.94	T. R.			
α^2	Centauri	14 23 1.01	7	− 1.02	....	−10.09	14 22 49.90	+0.01
α	Circini	14 22 50.90	9	− 1.02	....	−10.88	14 22 39.00	+0.39
γ	Lupi	15 18 44.26	8	− 1.20	....	− 8.55	15 18 34.51	+0.30
β	Lupi	14 42 25.95	6	− 1.09	....	− 8.37	14 42 16.49	+0.33
δ	Scorpii	15 45 44.44	8	− 1.03	F.			
α	Tria. a	16 22 44.28	8	− 1.42	....	−14.61	16 22 28.25	+0.51
	Antares	16 14 16.62	8	− 1.39	T. R.			
ε	Scorpii	16 34 10.94	7	− 1.46	....	− 8.42	16 34 1.06	+0.22
θ	Scorpii	17 19 34.04	8	− 1.61	....	− 9.26	17 19 23.17	+0.27
μ	Sagitt	17 58 58.28	8	− 1.53	F.			
β	Sagitt	18 39 54.67	8	− 1.91	F.			
φ	Sagitt	18 30 11.59	8	− 2.27	F.			

1751, JUNE 16. AT $16^h 0^m$: CORR'N $= -1^m 2^s.72 - 0^s.13$ h.

				m. s.				
	☉	5 38 22.24	3	−1 1.78	H. O.			
π	Lupi	14 49 25.86	6	− 1 2.57	....	− 8.71	14 48 14.58	+0.31
ρ	Scorpii	15 42 41.15	7	− 1 2.65	F.			
	Antares	16 15 18.14	7	− 1 2.79	T. R.			
α	Aræ	17 13 46.99	3	− 1 2.88	....	−10.33	17 12 33.78	−0.09
μ	Scorpii	16 36 11.20	7	− 1 2.80	....	− 8.87	16 34 59.53	+0.24

1751, JUNE 17. AT $15^h 24^m$: CORR'N $= -1^m 6^s.27 - 0^s.13$ h.

	☉	5 42 34.77	4	− 1 4.92	H. O.			
κ	Centauri	14 44 15.06	7	− 1 6.18	....	− 8.23	14 43 0.65	+0.17
β	Libræ	15 4 48.37	7	− 1 6.25	F.			
μ	Serpentis	15 37 48.86	7	− 1 6.28	F.			

I.—*Right Ascensions*—Continued.

1751, JUNE 27. AT $18^h\ 32^m$: CORR'N $= -1^m\ 53^s.20 - 0^s.108$ h.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. −Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	LaC. N.
	h. m. s.		*m. s.*		*s.*	*h. m. s.*	*s.*
Antares	16 16 8.35	7	−1 52.97	T. R.			
δ Aræ	17 10 42.45	6	−1 53.05	....	−12.54	17 8 36.86	+0.16
γ Aræ	17 6 30.07	7	−1 53.05	....	−11.49	17 4 25.53	+0.07
β Aræ	17 6 39.55	7	−1 53.05	....	−11.33	17 4 35.17	+0.05
ζ Aræ	16 40 6.93	6	−1 53.00	....	−11.20	16 38 2.73	+0.16
α Aræ	17 14 37.07	9	−1 53.05	....	−10.45	17 12 33.57	+0.12
η Scorpii	16 56 20.62	4	−1 53.02	....	− 9.54	16 54 18.06	+0.11
τ Sagitt	18 53 20.49	8	−1 53.26	F.			
ζ Sagitt	18 48 43.03	7	−1 53.25	F.			
β Capric	20 8 57.22	4	−1 53.32	F.			

1751, JUNE 28. AT $13^h\ 17^m$: CORR'N $= -1^m\ 59^s.43 - 0^s.317$ h.

Sirius	6 36 8.74	7	−1 57.42	A.			
⊙	6 29 11.23	5	−1 57.17	H. O.			
β Libræ	15 5 42.01	8	−1 59.75	F.			
δ Scorp	16 8 10.70	7	−2 0.43	F.			
Antares	16 16 15.88	7	−2 0.50	T. R.			
γ Scorpii	15 59 7.98	8	−2 0.19	F.			
τ Scorpii	16 22 30.50	7	−2 0.56	F.			
ζ Scorpii	16 39 13.02	7	−2 0.50	....	− 9.34	16 37 3.18	+0.11
η Pavonis	17 23 30.93	7	−2 0.73	....	−13.78	17 21 16.42	+0.23
κ Scorpii	17 27 23.08	7	−2 0.75	....	− 9.25	17 25 13.08	+0.13

1751, JULY 20. AT $19^h\ 40^m$: CORR'N $= -51^s.10 - 0^s.224$ h.

Sirius, 19th	6 34 59.50	7	− 47.90	A.			
⊙, 20th	7 57 58.77	6	− 47.98	H. O.			
Antares	16 15 5.80	8	− 50.51	T. R.			
α Telesc	18 9 26.62	7	− 50.76	....	−10.21	18 8 25.65	+0.05
θ Sagitt	18 50 40.55	7	− 50.66	F.			
ε Pavonis	19 32 20.60	5	− 51.08	....	−18.12	19 31 11.40	+0.24
π Sagitt	18 55 52.16	8	− 51.00	F.			
α Pavonis	20 6 44.06	8	− 51.20	....	−11.50	20 5 41.36	−0.03
δ Pavonis	19 45 0.95	7	− 51.12	....	−14.22	19 43 55.61	0.00
γ Pavonis	21 6 28.48	7	− 51.42	....	−12.57	21 5 24.49	−0.10
γ Gruis	21 39 42.27	9	− 51.55	....	− 8.31	21 38 42.41	−0.15
δ Capric	21 34 11.74	7	− 51.55	F.			
α Pisc. aust	22 44 45.68	9	− 51.76	T. R.			
⊙, 21st	8 2 5.41	7	− 54.44	H. O.			

1751, AUG. 4. AT $19^h\ 36^m$: CORR'N $= -7^s.67 + 0^s.130$ h.

Sirius, 3d	6 34 21.11	6	− 9.23	A.			
⊙. 4th	8 56 20.67	5	− 9.22	H. O.			
Antares	16 14 23.30	8	− 8.17	T. R.			
β^1 Sagitt	19 4 54.36	7	− 7.74	....	−10.08	19 4 36.54	+0.09
β^2 Sagitt	19 5 23.74	5	− 7.74	....	−10.11	19 5 5.89	+0.09
α Sagitt	19 6 48.20	7	− 7.74	....	− 9.66	19 6 30.80	+0.12
β Pavonis	20 22 25.98	8	− 7.57	....	−14.00	20 22 4.51	−0.01
α^1 Capric	20 4 1.28	6	− 7.27	T. R.			
α^2 Capric	20 4 24.95	7	− 7.38	T. R.			
β Indi	20 35 22.64	8	− 7.54	....	−11.70	20 35 3.40	+0.03
α Aquilæ	19 38 49.54	7	− 7.62	T. R.			
α Indi	20 20 9.47	6	− 7.57	....	−10.14	20 19 51.76	+0.07
α Tucanæ	22 1 24.98	8	− 7.36	....	−10.52	22 1 7.10	−0.01
α Gruis	21 52 37.07	8	− 7.37	....	− 9.13	21 52 20.57	−0.01
β Gruis	22 27 52.34	7	− 7.30	....	− 8.54	22 27 36.50	−0.23
φ Aquarii	23 1 35.95	7	− 6.96	F.			
δ Aquarii	22 41 35.72	8	− 7.17	F.			
Sirius, 4th	6 34 18.84	7	− 6.95	A.			

I.—*Right Ascensions*—Continued.

1751, AUGUST 22. AT $20^h\ 16^m$: CORR'N $= +1^m\ 9^s.09 + 0^s.18$ h.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. − Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	LaC. N.
	h. m. s.		m. s.		s.	h. m. s.	
Sirius, 21st	6 33 5.45	8	+1 6.82	A.			
⊙, 22d	10 3 0.01	5	1 7.08	H. O.			
λ Scorpii	17 15 39.68	7	1 8.55	....	− 8.67	17 16 39.56	+0.39
υ Scorpii	17 12 47.95	7	+1 8.55	....	8.67	17 13 47.83	+0.30
β Capric	20 5 54.97	6	+1 9.44	F.			
Sirius, 22d	6 33 1.20	6	+1 11.10	A.			
⊙, 23d	10 6 37.72	5	+1 11.01	H. O.			

1751, SEPTEMBER 13. AT 23^h: CORR'N $= +6.09 + 0.402$ h.

α Aquilæ	19 38 36.98	8	+ 4.58	T. R.			
β Aquarii	21 18 24.95	7	+ 5.40	F.			
α Aquarii	21 52 57.67	8	+ 5.73	T. R.			
γ Aquarii	22 8 45.80	6	+ 5.66	F.			
α Pisc. aust	22 43 48.68	8	+ 6.05	T. R.			
γ Tucanæ	23 2 42.41	7	+ 6.09	....	− 9.50	23 2 39.00	+0.81
β Hydri	0 12 14.37	3	+ 6.57	....	−10.72	0 12 10.22	+1.80
α Eridani	1 28 21.29	7	+ 7.09	....	− 6.28	1 28 22.10	+0.82
β Phœnicis	0 54 52.37	7	+ 6.85	....	− 7.00	0 54 52.22	+0.63
δ Phœnicis	1 20 47.35	7	+ 7.03	....	− 6.56	1 20 47.83	+0.61
γ Phœnicis	1 17 27.86	7	+ 7.01	....	− 6.78	1 17 28.09	+0.62
α Argûs	6 18 17.45	7	+ 9.02	....	− 2.19	6 18 24.28	+0.12
Sirius	6 34 3.75	6	+ 9.11	A.			

1751, SEPTEMBER 30. AT $21^h\ 28^m.5$: CORR'N $= +2^m\ 16^s.525 + 0^s.3385$ h.

Sirius, 29th	6 32 1.68	4	+2 11.64	A.			
⊙, 30th	12 23 3.16	4	+2 13.29	H. O.			
β Octantis	22 16 40.35	4	+2 16.80	....	−22.24	22 18 34.91	+1.02
δ Hydri	2 15 10.26	4	+2 18.14	....	− 4.88	2 17 23.52	+0.21
Sirius, 30th	6 31 53.85	6	+2 19.50	A.			
⊙, 31st	12 26 32.14	7	+2 21.67	H. O.			

1751, OCTOBER 6. AT $6^h\ 31^m$: CORR'N $= +3^m\ 10^s.42 + 0^s.40$ h.

⊙	12 44 1.83	4	+3 3.39	H. O.			
α Argûs	6 15 16.99	3	+3 10.31	....	− 3.13	6 18 24.17	+0.23
Sirius	6 31 3.09	8	+3 10.42	A.			

OCTOBER 7. AT $2^h\ 13^m$: CORR'N $= +3^m\ 18^s.43 + 0^s.385$ h.

⊙, 7th	12 47 31.54	7	+3 13.06	H. O.			
β Hydri	0 9 4.84	6	+3 17.63	....	−10.77	0 12 11.70	+0.32
α Phœnicis	0 10 41.60	8	+3 17.65	....	− 7.68	0 13 51.57	+0.55
γ Pegasi	23 57 13.45	7	3 17.71	T. R.			
α Hydri	1 47 40.79	8	+3 18.27	....	− 6,16	1 50 52.90	+0.67
α Fornacis	2 58 15.05	8	+3 18.72	....	− 6.38	3 1 27.39	+0.61
θ Eridani	2 45 34.41	7	+3 18.64	....	− 6.07	2 48 46.98	+0.57
α Argûs	6 15 7.62	6	+3 19.98	....	− 3.17	6 18 24.43	−0.03
Sirius	6 30 53.15	9	+3 20.39	A.			
⊙, 8th	12 51 1.77	8	+3 22.32	H. O.			

1751, OCTOBER 8. AT $1^h\ 28^m$: CORR'N $= +3^m\ 27^s.96 + 0^s.395$ h.

⊙, 8th	12 51 2.77	8	+3 22.32	H. O.			
λ Aquarii	22 36 14.11	5	+3 27.12	F.			
ζ Tucanæ	0 3 33.55	4	+3 27.41	....	− 8.70	0 6 52.26	+0.65
λ Hydri	0 36 31.70	5	+3 27.62	....	− 8.79	0 39 50.53	+0.84
β Ceti	0 27 41.40	7	+3 27.92	F.			
β Tucanæ	0 16 39.15	4	+3 27.49	....	− 8.25	0 19 58.39	+0.59
Sirius	6 30 43.36	7	+3 30.21	A.			
⊙, 9th	12 54 32.11	7	+3 32.22	H. O.			

I.—*Right Ascensions*—Continued.

1751, OCTOBER 26. CORR'N = −56.44.

	Nomen.	Culmin. Clock-time.	Num.	A. R. app. −Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	LaC. N.
		h. m. s.		m. s.		s.	h. m. s.	
α	Doradûs	4 29 37.65	8	− 56.44	....	− 4.47	4 28 36.74	+0.67
53	Eridani	4 27 48.08	6	− 56.52	F.			
υ^2	Eridani	4 26 52.91	7	− 56.35	F.			
	Sirius	6 35 10.60	6	− 56.52	A.			

1751, NOVEMBER 5. AT $0^h\ 0^m$: CORR'N = $-1^m\ 32^s.63 - 0.282$ h.

	Sirius, 4th	6 35 42.30	9	−1 27.97	A.			
	⊙, 5th	14 42 28.38	7	−1 29.76	H. O.			
α	Eridani	1 30 2.29	5	−1 33.05	....	− 6.69	1 28 22.55	+0.37
η	Phœnicis	0 33 42.26	8	−1 32.79	....	− 7.46	0 32 1.60	+0.63
μ	Hydri	2 39 22.99	3	−1 33.38	....	− 2.53	2 37 47.08	+0.79
κ	Hydri	2 23 16.62	3	−1 33.30	....	− 4.59	2 21 38.73	+0.54
γ	Hydri	3 53 2.49	5	−1 33.72	....	− 1.98	3 51 26.79	+0.68
α	Reticuli	4 12 54.21	7	−1 33.82	....	− 4.06	4 11 16.33	+0.56
ζ	Eridani	4 10 7.02	6	−1 33.80	....	− 6.25	4 8 26.97	+0.48
β	Leporis	5 19 13.11	9	−1 34.06	F.			
	Sirius, 5th	6 35 48.69	10	−1 34.33	A.			
	⊙, 6th	14 46 34.54	7	−1 37.01	H. O.			

1751, DECEMBER 3. CORR'N = $+35^s.90$.

	⊙, 3d	16 37 6.35	5	+ 35.95	H. O.			
ζ	Eridani	3 38 53.24	6	+ 35.90	....	− 6.38	3 39 22.76	+0.35
δ	Mons mensæ	4 35 5.44	4	+ 35.90	....	+ 2.47	4 35 43.81	+0.46
δ	Cæli Sculp	4 22 41.96	8	+ 35.90	....	− 5.84	4 23 12.02	+0.38
δ	Leporis	5 40 5.92	7	+ 35.88	F.			
	Sirius	6 33 39.10	7	+ 35.93	A.			
β	Columbæ	5 41 40.12	7	+ 35.90	....	− 6.27	5 42 9.75	+0.35
	⊙, 4th	16 41 27.39	7	+ 35.72	H. O.			

1751, DECEMBER 10. CORR'N = $+29^s.19$.

	⊙	17 7 49.70	7	+ 29.62	H. O.			
β	Reticuli	3 40 45.19	8	+ 29.19	....	− 4.05	3 41 10.33	+0.66
α	Columbæ	5 30 13.52	7	+ 29.19	....	− 6.47	5 30 36.24	+0.61
β	Orionis	5 2 10.79	8	+ 29.07	T. R.			
α	Leporis	5 21 20.91	8	+ 28.99	F.			
	Sirius	6 33 45.72	7	+ 29.44	A.			
δ	Columbæ	6 12 36.51	6	+ 29.19	....	− 6.50	6 12 59.20	+0.57
ζ	Can. mj	6 10 20.86	9	+ 29.09	F.			
τ	Argus	6 43 19.90	5	+ 29.19	....	− 5.38	6 43 43.71	+0.30

1751, DECEMBER 11. CORR'N = $+27^s.72$.

	⊙	17 12 14.77	7	+ 28.92	H. O.			
α	Ceti	2 48 54.25	7	+ 28.28	T. R.			
l	Eridan	3 42 43.74	6	+ 27.87	F.			
	Sirius	6 33 47.58	8	+ 27.60	A.			
γ	Argus	6 29 45.02	7	+ 27.72	....	− 5.93	6 30 6.81	+0.17
δ	Can. mj	6 57 52.83	8	+ 27.84	F.			

1751, DECEMBER 20. CORR'N = $+4^s.34$.

	⊙	17 52 30.81	7	+ 6.06	H. O.			
γ	Lepor	5 34 5.64	8	+ 4.42	F.			
β	Dorad	5 31 29.07	5	+ 4.34	....	− 4.02	5 31 29.39	+0.20
	Sirius	6 34 11.18	8	+ 4.14	A.			
β	Can. mj	6 11 44.68	8	+ 4.45	F.			
α	Equid. Pict	6 45 57.56	8	+ 4.34	....	− 4.37	6 45 37.53	+0.24
τ	Argus	7 8 21.12	8	+ 4.34	....	− 6.50	7 8 18.96	+0.08

I.—*Right Ascensions*—Continued.

1751, DECEMBER 24. Corr'n= $-7^s.20$.

	Nomen.	Culmin. Clock-time.	Num.	A. R. app. −Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. −N.
		h. m. s.		s.		s.	h. m. s.	s.
ε	Orionis	5 23 47.56	8	− 6.96	F.			
δ	Orionis	5 19 30.45	7	− 7.53	F.			
ζ	Orionis	5 28 25.04	7	− 7.79	F.			
	Sirius	6 34 22.26	8	− 6.89	A.			
ν	Doradûs	6 10 31.75	6	− 7.20	....	− 2.95	6 10 21.60	+0.68
κ	Orionis	5 36 9.68	7	− 7.43	F.			
ε	Can. mj	6 49 2.11	8	− 6.97	F.			
α	Can. min	7 26 27.59	8	− 7.08	T. R.			
σ	Argûs	7 21 31.70	7	− 7.20	....	− 6.24	7 21 18.26	+0.53
ξ	Argûs	7 39 1.07	7	− 6.98	F.			
	☉ 25th	18 14 58.78	7	− 8.13	H. O.			

1752, JANUARY 9. Corr'n= −47.24.

	☉	19 21 46.78	7	− 46.51	H. O.			
α	Orionis	5 42 34.76	8	− 47.26	T. R.			
	Sirius	6 35 2.94	8	− 47.46	A.			
δ	Pisc. vol	7 17 44.30	6	− 47.24	....	− 3.98	7 16 53.08	+0.23
τ	Argûs	6 44 36.55	4	− 47.24	....	− 5.66	6 43 43.65	+0.36
α	Monocer	·7 30 13.42	7	− 47.10	F.			
α	Can. min	7 27 7.85	7	− 47.15	T. R.			

1752, JANUARY 10. AT $7^h 42^m$: Corr'n= $-49^s.47 - 0^s.107$ h.

	☉ 10th	19 26 10.08	7	− 48.45	H. O.			
	Sirius	6 35 4.55	7	− 49.07	A.			
γ	Arg. luc	8 2 45.85	8	− 49.51	....	− 6.43	8 1 49.91	+0.63
θ	Argûs	8 34 3.28	7	− 49.56	....	− 6.37	8 33 7.35	+0.65
β	Argûs	9 11 15.49	6	− 49.63	....	− 5.64	9 10 20.22	+1.46
λ	Argûs	8 59 45.14	7	− 49.61	....	− 7.02	8 58 48.51	+0.66
α	Hydræ	9 16 15.82	7	− 49.73	T. R.			
	☉ 11th	19 30 33.07	7	− 50.63	H. O.			

1752, JANUARY 22. Corr'n= $-1^m 13^s.76$.

	☉ 22d	20 18 0.32	7	−1 12.46	H. O.			
	Sirius	6 35 29.21	7	−1 13.71	A.			
ε	Argûs	8 18 41.01	9	−1 13.76	....	− 5.84	8 17 21.41	+0.06
ζ	Argûs	7 56 8.79	7	−1 13.76	....	− 6.88	7 54 48.15	+0.16
α	Argûs	7 44 58.22	7	−1 13.76	....	− 6.76	7 43 37.70	+0.13
β	Cancri	8 4 19.05	7	−1 13.69	F.			
υ	Argûs	9 42 11.47	7	−1 13.76	....	− 6.88	9 40 50.83	−0.13
o	Leonis	9 29 9.81	7	−1 13.87	F.			
	☉ 23d	20 22 16.26	6	−1 16.03	H. O.			

1752, FEBRUARY 4. AT $8^h 8^m$: Corr'n= $-1^m 47^s.975 - 0^s.090$ h.

	☉ 4th	21 12 11.27	7	−1 46.98	H. O.			
	Sirius	6 36 3.25	8	−1 47.83	A.			
α	Can. min	7 28 8.73	7	−1 47.94	T. R.			
δ	Argûs	8 39 42.62	9	−1 48.02	....	− 6.48	8 37 48.12	+0.25
α	Chamæl	8 26 25.16	6	−1 48.00	....	− 2.95	8 24 34.21	+0.34
α	Pisc. vol	9 0 20.83	7	−1 48.05	....	− 6.01	8 58 26.77	+0.35
φ	Argûs	9 50 2.75	7	−1 48.13	....	− 7.55	9 48 7.07	+0.43
κ	Argûs	9 16 18.35	7	−1 48.08	....	− 7.02	9 14 23.25	+0.29
ω	Argûs	10 9 42.63	5	−1 48.16	....	− 7.66	10 7 46.81	+0.38
η	Argûs	10 37 22.16	9	−1 48.20	....	− 8.30	10 35 25.66	+0.35
p	Argûs	10 25 7.74	8	−1 48.18	....	− 7.86	10 23 11.70	+0.13
λ	Centauri	11 26 20.60	7	−1 48.27	....	− 9.29	11 24 23.04	+0.39
	☉ 5th	21 16 15.09	7	−1 49.15	H. O.			

I.—*Right Ascensions*—Continued.

1752, February 13. At $13^h.6$: Corr'n $= -1^m\ 39^s.154 + 0^s.1116$ h.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. —N.
	h. m. s.		s.		s.	h. m. s.	s.
Sirius	6 35 55.11	8	−1 39.78	A.			
α Can. min	7 28 0.74	8	−1 39.96	T. R.			
ζ Octantis	9 29 51.25	4	−1 39.61	....	−2.33	9 28 9.31	+0.57
G Argûs	9 6 4.81	6	−1 39.65	....	−5.40	9 4 19.76	+0.43
β Argûs	9 12 7.20	6	−1 39.64	....	−5.95	9 10 21.61	+0.07
ι Argûs	9 12 10.21	8	−1 39.64	....	−6.74	9 10 23.83	+0.42
η Octantis	11 2 8.3	2	−1 39.44	....	−12.97	11 0 15.9	+0.9
T Argûs	10 21 9.7	4	−1 39.51	....	−8.19	10 19 22.0	+0.64
α Hydr. med	11 21 43.60	5	−1 39.52	F.			
δ Centauri	11 57 19.74	8	−1 39.34	....	−9.37	11 55 31.03	+0.38
ε Corvi	11 59 6.68	7	−1 39.24	F.			
Sirius	6 35 52.59	5	−1 37.27	A.			

1752, February 27. At $10^h\ 0^m$: Corr'n $= -31^s.635 + 0^s.241$ h.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. —N.
☉ 27th	22 40 26.37	7	− 34 48	H. O.			
Sirius	6 34 47.49	8	− 32.26	A.			
θ Argûs	10 34 46.01	8	− 31.50	....	−8.54	10 34 5.97	+0.46
δ Chamæl	10 43 53.12	4	− 31.46	....	−10.09	10 43 11.57	+0.50
μ Argûs	10 36 44.39	8	− 31.49	....	−8.47	10 36 4.43	+0.40
π Chamæl	11 27 52.65	6	− 31.28	....	−11.54	11 27 9.83	+0.45
α Crateris	10 48 16.68	7	− 31.24	F.			
ξ Hydræ	11 21 25.46	7	− 31.42	F.			
γ Centauri	12 28 32.34	7	− 31.04	....	−9.98	12 27 51.32	+0.39
☉ 28th	22 44 5.84	5	− 28.67	H. O.			

1752, March 30. At $13^h\ 10^m.6$: Corr'n $= +1^m\ 34^s.40 + 0^s.12$ h.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. —N.
Sirius	6 32 40.94	7	+1 33.58	A.			
β Centauri	13 45 5.57	8	+1 34.47	....	−13.12	13 46 26.92	−0.01
α Virginis	13 10 38.50	8	+1 34.40	T. R.			
κ Centauri	13 36 5.35	7	+1 34.46	....	−10.24	13 37 29.57	+0.23

1752, April 5. At $11^h\ 35^m$: Corr'n $= -7^s.31 + 0^s.143$ h.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. —N.
☉ 5th	0 59 11.91	7	− 8.97	H. O.			
Sirius	6 34 22.50	8	− 8.08	A.			
λ Chamæl	11 55 22.50	4	− 7.26	....	−12.93	11 55 2.31	+0.24
κ Chamæl	11 52 36.41	5	− 7.27	....	−13.14	11 52 16.00	+0.21
β Virginis	11 37 56.86	7	− 7.40	T. R.			
ρ Centauri	11 59 0.23	6	− 7.25	....	−10.06	11 58 42.92	+0.25
γ Corvi	12 3 15.27	7	− 7.08	F.			
α Virginis	13 12 19.66	6	− 6.91	T. R.			
g Centauri	13 35 20.49	6	− 7.02	....	−10.38	13 35 3.09	+0.18
ν Centauri	13 34 55.62	7	− 7.02	....	−10.84	13 34 37.80	+0.12
☉ 6th	1 2 47.52	7	− 5.76	H. O.			

1752, April 16. At $15^h\ 20^m$: Corr'n $= +13^s.10 + 0^s.073$ h.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. —N.
Sirius 16th	6 34 1.61	7	+ 12.60	A.			
β Chamæl	12 4 18.8	3	+ 12.86	....	−15.12	12 4 16.5	+0.8
ε Crucis	12 8 0.64	3	+ 12.87	....	−10.81	12 8 2.70	+0.55
β Crucis	12 33 16.85	8	+ 12.90	....	−11.58	12 33 18.17	+0.66
α Crucis	12 12 53.54	6	+ 12.87	....	−11.24	12 12 55.17	+0.59
ε Corvi	11 57 15.08	8	+ 12.49	F.			
γ Crucis	12 17 25.37	9	+ 12.88	......	−10.77	12 17 27.48	+0.53
κ Virginis	13 59 31.95	6	+ 13.10	F.			
ι Lupi	14 3 30.10	7	+ 13.01	....	−11.69	14 3 31.42	+0.52
Sirius 17th	6 33 59.97	7	+ 14.22	A.			

I.—*Right Ascensions*—Continued.

1752, April 22. Corr'n=+20s.03.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. —N.
	h. m. s.		s.		s.	h. m. s.	s.
Sirius	6 33 54.15	7	+ 19.96	A.			
δ Crucis	12 1 52.44	8	+ 20.03	....	−10.43	12 2 2.04	+0.45
γ Muscæ	12 17 46.97	6	+ 20.03	....	−12.97	12 17 54.03	+0.56
δ Muscæ	12 45 23.43	7	+ 20.03	....	−14.16	12 45 29.30	+0.53
α Muscæ	12 22 26.96	7	+ 20.03	....	−12.49	12 22 34.50	+0.42
μ Centauri	13 34 31.20	7	+ 20.03	....	−11.05	13 34 40.18	+0.48
γ Virginis	12 28 49.23	8	+ 19.83	F.			
ζ Virginis	13 21 47.29	8	+ 20.08	F.			
θ Virginis	12 56 50.87	3	+ 20.21	F.			

1752, April 23. Corr'n=+20s.28.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. —N.
Sirius	6 33 53.86	8	+ 20.23	A.			
β Muscæ	12 31 7.50	7	+ 20.28	....	−12.63	12 31 15.15	+0.56
α Corvi	11 55 22.92	4	+ 20.26	F.			
η Virginis	12 6 55.66	5	+ 20.76	F.			
δ Virginis	12 42 49.77	3	+ 20.11	F.			
δ Octantis	13 50 12.7	3	+ 20.28	....	−31.97	13 50 1.0	+ 0.9

1752, April 28.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. —N.
Sirius	6 33 48.52	8	+ 25.50	A.			
δ Corvi	12 16 40.99	8	+ 25.23	F.			
α Virginis	13 11 46.41	8	+ 26.43	T. R.			
α Corvi	11 55 16.88	5	+ 26.24	F.			
η Virginis	12 6 49.85	7	+ 26.55	F.			
θ Virginis	12 56 44.61	7	+ 26.37	F.			
δ Virginis	12 42 43.96	8	+ 25.91	F.			
Sirius	6 33 46.89	7	+ 27.11	A.			

1752, May 1. At 13h 14m: Corr'n=+29s.66+0s.090 h.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. —N.
Sirius 1st	6 33 45.09	8	+ 28.89	A.			
ε Chamæl	11 47 20.43	5	+ 29.53	....	−12.54	11 47 37.42	+0.46
β Corvi	12 20 57.95	8	+ 30.21	F.			
α Virginis	13 11 43.04	7	+ 29.81	T. R.			
α Libræ	14 36 45.61	8	+ 30.10	T. R.			
δ Ophiuchi	16 0 55.53	8	+ 30.10	F.			
α Serpentis	15 31 37.53	7	+ 29.77	T. R.			
δ Serpentis	15 22 31.69	7	+ 29.41	F.			
ε Serpentis	15 38 1.63	7	+ 29.65	F.			
ζ Ophiuchi	16 23 5.26	8	+ 29.60	F.			
α Scorpii	16 13 48.64	7	+ 29.71	T. R.			
β Ophiuchi	17 30 46.67	7	+ 29.91	F.			
ζ Serpentis	17 46 56.70	7	+ 29.65	F.			
Sirius 2d	6 33 43.76	5	+ 30.20	A.			

1752, June 11. Corr'n=+13s.56.

Nomen.	Culmin. Clock-time.	Num.	A. R. app. —Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. —N.
☉	5 19 31.33	6	+ 13.64	H. O.			
Sirius 11th	6 34 0.27	7	+ 13.47	A.			
β Libræ	15 3 31.49	8	+ 13.72	F.			
ε Ophiuchi	16 5 3.64	7	+ 13.42	F.			
ε Aræ	16 39 46.55	6	+ 13.56	....	−15.21	16 39 44.90	+0.30
β Serpentis	15 34 34.75	5	+ 13.58	F.			
α Scorpii	16 14 5.49	8	+ 13.39	T. R.			
η Ophiuchi	16 56 0.68	8	+ 13.94	F.			
ζ Pavonis	18 13 52.86	6	+ 13.56	....	−23.38	18 13 43.04	+0.27
ι Antinoi	19 23 43.11	8	+ 13.25	F.			
η Serpentis	18 8 19.0	1	+ 13.8	F.			
λ Antinoi	18 52 55.0	2	+ 13.67	F.			
θ Oph. præc	18 43 43.22	6	+ 13.93	F.			
η Antinoi	19 39 39.72	7	+ 13.68	F.			
θ Antinoi	19 58 19.74	8	+ 13.44	F.			
Sirius 12th	6 34 0.68	7	+ 13.07	A.			

I.—*Right Ascensions*—Continued.

1752, NOVEMBER 8. AT $0^h.3$: Corr'n$=+57^s.53+0^s.08$ h.

	Nomen.	Culmin. Clock-time.	Num.	A. R. app. −Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. −N.
		h. m. s.		s.		s.	h. m. s.	s.
λ	Phœnicis	0 18 29.75	7	+ 57.53	....	− 9.96	0 19 17.32	+0.34
θ	Ceti	1 10 44.70	7	+ 57.60	F.			
	Sirius	6 33 18.78	7	+ 58.04	A.			

1752, NOVEMBER 9. AT $1^h\ 58^m$: Corr'n$=+59^s.44+0^s.09$ h.

	Nomen.	Culmin. Clock-time.	Num.	A. R. app. −Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. −N.
θ	Ceti	1 10 43.13	7	+ 59.17	F.			
χ	Eridani	1 45 22.13	8	+ 59.42	....	− 8.50	1 46 12.95	+0.80
α	Piscium..........	1 48 19.65	7	+ 59.02	F.			
δ	Eridani..........	3 30 27.95	6	+ 59.45	F.			
δ	Ceti	2 25 52.96	8	+ 59.08	F.			
γ	Eridani	3 45 32.87	7	+ 59.75	F.			
ε	Eridan............	3 58 51.57	6	+ 59.73	F.			
53α	Eridani	4 25 54.73	7	+ 59.64	F.			
54α	Eridani	4 28 40.66	8	+ 59.79	F.			
β	Eridani	4 54 44.93	8	+ 59.63	F.			
	Sirius	6 33 16.80	8	+ 60.15	A.			

NOVEMBER 10.

	Nomen.	Culmin. Clock-time.	Num.	A. R. app. −Culm.	Auc.	Red. in 1750.0.	A. R. med. 1750.0.	La C. −N.
	⊙................	15 3 5.27	7	+1 1.35	H. O.			
ε	Ceti	2 26 37.29	7	+1 2.07	F.			
γ	Ceti	2 29 30.60	7	+1 2.64	F.			
ζ	Eridani	3 2 50.50	7	+1 2.25	F.			
ε	Eridani	3 20 17.84	8	+1 2.15	F.			
	Sirius	6 33 14.48	7	+1 2.50	A.			

II.

SEXTANT AT PARIS TILL 1756, APRIL 21. Corr'n $= +9''.75 \sin\delta - 7''.10 \cos\delta$.

	Name.	Time of observation.	Mean declination 1750.0.	No. of observations.	Bradley.	Corr'n		Names.	Time of observation.	Mean declination 1750.0.	No. of observations.	Bradley.	Corr'n
			° ′ ″		″	″				° ′ ″		″	″
	Polaris, S. P	55.7	+92 1 47.1	12	−10.3	+10.0	γ	Pegasi	55.9	13 47 41.1	1	+ 7.3	− 4.6
	Polaris............	55.8	87 57 53.1	17	− 9.5	+ 9.6	γ	Aquilæ	55.8	10 1 26.8	3	+ 3.6	− 5.3
β	Urs. min..........	55.5	75 10 29.2	7	−10.9	+ 7.6	ζ	Pegasi	55.8	9 32 14.8	5	+14.2	− 5.4
γ	Urs. min..........	55.5	72 43 18.4	6	− 2.0	+ 7.2	ε	Pegasi	55.8	8 44 35.1	7	+ 6.9	− 5.5
η	Urs. maj..........	55.4	50 34 6.9	11	− 3.4	+ 3.0	α	Aquilæ	55.8	8 13 48.5	6	+ 6.6	− 5.6
ι	Urs. maj..........	56.2	48 59 57.3	12	−10.0	+ 2.7	α	Orionis	56.2	7 20 17.2	4	+ 6.9	− 5.8
κ	Urs. maj..........	56.3	48 7 21.6	13	− 6.2	+ 2.5	γ	Orionis	56.2	6 6 0.3	5	+ 1.4	− 6.0
δ	Persei	56.2	46 57 42.8	15	− 1.9	+ 2.3		Procyon	56.2	5 50 41.5	5	+ 5.3	− 6.0
α	Aurigæ	56.2	45 42 39.4	12	+ 1.0	+ 2.0	β	Aquilæ	55.8	5 48 10.8	5	+ 7.5	− 6.1
η	Tauri	56.1	23 18 41.2	4	+ 4.1	− 2.6	α	Ceti	56.1	3 5 37.3	5	+ 2.3	− 6.5
μ	Geminorum........	56.2	22 36 55.6	5	+ 2.0	− 2.8	γ	Ceti	56.1	2 10 5.2	5	+ 1.6	− 6.7
η	Geminorum........	56.2	22 33 12.8	4	+ 4.8	− 2.8	α	Piscium...........	56.1	+ 1 32 48.4	3	+ 5.6	− 6.0
α	Arietis............	56.1	22 16 4.6	4	+ 3.1	− 2.9	δ	Orionis	56.2	− 0 30 15.5	5	+ 6.9	− 7.2
β	Arietis............	56.1	19 34 30.2	4	+ 3.0	− 3.4	ε	Orionis	56.2	− 1 22 52.0	5	+10.7	− 7.4
ε	Tauri	56.1	18 36 10.8	8	+ 5.2	− 3.6	ζ	Orionis	56.2	− 2 5 41.5	5	+ 9.1	− 7.4
δ¹	Tauri	56.2	16 56 5.5	8	+ 7.8	− 3.9	ο	Ceti...............	56.1	− 4 7 33.1	3	....	− 7.7
δ²	Tauri	56.2	16 50 35.5	3	+ 7.6	− 3.9	β	Eridani	56.2	− 5 25 48.3	5	+ 4.8	− 8.0
α	Tauri	56.1	15 59 5.1	8	+10.0	− 4.1	β	Aquarii...........	55.8	− 6 39 17.3	7	+ 7.5	− 8.2
β	Leonis	55.9	15 58 14.6	1	+10.1	− 4.1	φ	Aquarii...........	55.9	− 7 23 23.0	3	+ 9.5	− 8.3
γ	Tauri	56.1	15 0 9.8	8	+ 6.6	− 4.3	α	Hydræ	56.2	− 7 35 12.4	4	+ 6.8	− 8.3
α	Pegasi	55.9	13 52 3.9	4	+10.1	− 4.5		Rigel	56.2	− 8 30 32.2	5	+ 8.6	− 8.5

Declinations.

IIa.

SEXTANT AT PARIS AFTER 1756, APRIL 21. Corr'n = $+12.2 \sin \delta - 11.7 \cos \delta$.

Name.	Time of observation.	Mean declination 1750.0.	No. of observations.	= Bradley.	Corr'n.	Name.	Time of observation.	Mean declination 1750.0.	No. of observations.	= Bradley.	Corr'n.
		° ′ ″		″	″			° ′ ″		″	″
Polaris, S. P	56.4	+92 1 44.2	4	−13.2	+12.8	ο Leonis	56.8	11 1 10.5	5	+13.8	− 9.2
Polaris	56.6	87 57 52.1	4	−10.5	+11.8	ρ Leonis	56.8	10 35 19.9	5	+15.5	− 9.3
γ *Draconis*	56.7	51 31 40.8	5	− 3.8	+ 2.2	γ Aquilæ	56.8	10 1 28.2	5	+ 5.0	− 9.4
η *Urs. maj.*	56.4	50 34 7.9	10	− 2.4	+ 2.0	β Can. min.	56.8	8 46 28.8	5	+14.6	− 9.7
μ Leonis	56.4	27 10 19.7	6	+ 5.1	− 4.9	α Aquilæ	56.8	8 13 49.2	4	+ 7.4	− 9.8
ε Leonis	56.9	24 54 42.8	5	+ 2.2	− 5.5	α Orionis	56.8	7 20 22.9	3	+12.6	−10.0
ζ Leonis	56.8	24 39 9.7	5	+ 5.6	− 5.6	α Serpentis	56.4	7 14 3.3	7	+14.4	−10.1
μ Geminorum	56.8	22 36 54.4	3	+ 0.8	− 6.1	Procyon	56.8	5 50 46.3	3	+10.1	−10.4
η Geminorum	56.8	22 33 10.9	3	+ 2.9	− 6.1	β Aquilæ	56.8	5 48 10.5	4	+ 7.2	−10.4
δ Geminornm	56.9	22 25 4.4	5	+ 2.5	− 6.2	ε Serpentis	56.5	5 15 12.1	6	+15.9	−10.5
γ Cancri	56.9	22 20 58.2	5	+11.3	− 6.2	δ Virginis	56.7	4 45 53.2	7	+10.5	−10.6
α Arietis	56.8	22 16 6.9	2	+ 5.4	− 6.2	β Ophiuchi	56.5	4 41 51.2	6	+13.5	−10.7
β Herculis	56.5	22 3 12.9	8	+ 5.7	− 6.3	β Virginis	56.7	3 10 31.4	6	+10.7	−11.0
δ Leonis	56.9	21 53 19.7	5	+ 0.2	− 6.3	α Ceti	56.9	3 5 45.2	1	+10.2	−11.0
γ Leonis	56.8	21 5 49.7	5	+ 7.9	− 6.5	γ Ophiuchi	56.5	2 49 35.8	6	+ 9.8	−11.1
ζ Tauri	57.0	20 57 50.0	6	+ 0.8	− 6.6	δ Aquilæ	56.8	2 38 29.5	6	+15.6	−11.1
ζ Geminorum	56.8	20 54 45.4	5	+ 3.7	− 6.6	γ Ceti	56.9	2 10 15.0	1	+11.4	−11.2
Arcturus	56.5	20 29 34.5	9	+ 3.1	− 6.7	α Piscium	56.8	1 33 0.4	2	+17.6	−11.4
γ Herculis	56.5	19 45 34.6	5	+ 6.2	− 6.9	η Virginis	56.9	0 43 41.3	6	....	−11.5
η Boötis	56.4	19 39 48.9	7	+11.2	− 6.9	ζ Virginis	56.4	0 41 35.6	6	+ 8.8	−11.5
δ Cancri	56.8	19 3 21.4	5	+ 8.0	− 7.0	η Antinoi	56.8	+ 0 23 15.9	4	+ 9.3	−11.6
γ Arietis	56.9	18 3 40.2	5	+16.6	− 7.4	γ Virginis	56.4	− 0 4 12.6	5	+13.4	−11.7
η Leonis	56.8	17 58 28.5	6	+16.3	− 7.4	δ Ceti	56.9	− 0 45 39.4	3	+10.4	−11.9
θ Leonis	57.0	16 47 37.9	3	+11.4	− 7.7	α Aquarii	56.8	− 1 31 11.9	6	+11.8	−12.0
γ Geminorum	56.8	16 35 21.9	5	+ 9.1	− 7.8	θ Antinoi	56.8	− 1 32 22.8	5	+12.6	−12.0
γ Serpentis	56.5	16 19 42.0	5	+ 6.3	− 7.8	ι Antinoi	56.8	− 1 48 57.2	6	+14.3	−12.1
β Serpentis	56.5	16 13 25.6	6	+10.8	− 7.9	γ Aquarii	56.8	− 2 38 03.2	6	+12.0	−12.2
β Leonis	56.4	15 58 12.4	4	+ 7.9	− 7.9	η Orionis	56.9	− 2 38 52.6	5	+ 3.8	−12.2
ζ Boötis	56.4	14 49 2.5	6	+11.4	− 8.2	δ Ophiuchi	56.5	− 3 1 38.9	6	+10.9	−12.3
ε Aquilæ	56.8	14 45 1.1	5	+ 4.4	− 8.3	ε Ophiuchi	56.5	− 4 3 35.2	6	+ 6.8	−12.5
α Herculis	56.5	14 41 51.2	6	+ 8.1	− 8.3	θ Virginis	56.7	− 4 11 39.0	6	+11.6	−12.5
α Pegasi	56.8	13 52 3.5	4	+ 9.7	− 8.5	φ Aquarii	56.8	− 7 23 22.0	3	+10.5	−13.2
γ Pegasi	56.8	13 47 40.2	4	+ 6.4	− 8.5	α Hydræ	56.4	− 7 35 8.5	3	+10.7	−13.2
ζ Aquilæ	56.8	13 30 50.5	5	+10.8	− 8.6	β Libræ	56.5	− 8 26 18.3	6	+14.3	−13.4
α Leonis	56.6	13 10 57.4	12	+17.9	− 8.6	Rigel	56.8	− 8 30 27.1	2	+13.7	−13.4
α Cancri	56.8	12 48 41.1	6	....	− 8.7	λ Aquarii	56.8	− 8 53 50.8	5	+18.8	−13.5
α Ophiuchi	56.5	12 45 51.1	6	+ 7.9	− 8.7	θ Ceti	56.8	− 9 23 36.5	5	+17.3	−13.6
ε Virginis	56.7	12 18 39.9	7	+ 8.3	− 8.8	ζ Eridani	57.0	− 9 45 38.1	5	− 7.7	−13.7
δ Serpentis	56.5	11 23 37.2	6	+ 9.5	− 9.1	α Virginis	56.6	− 9 50 36.1	11	+16.2	−13.7

Declinations—Continued.

III.

SECTOR AT PARIS. Corr'n = + 12″.34 sin δ − 9″.35 cos δ.

Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.
		° ′ ″	″	″
β Cephei	50.5	+69 27 52.0	−12.1	+ 8.3
δ Draconis	49.8	67 13 15.1	− 6.2	+ 7.8
α Draconis	49.4	65 34 32.9	− 7.0	+ 7.4
α Urs. mj	49.4	63 5 34.6	− 4.1	+ 6.8
ε Cassiopeæ	50.4	62 25 19.9	− 6.8	+ 6.6
η Draconis	49.5	62 4 59.9	− 7.4	+ 6.5
α Cephei	50.0	61 31 55.9	− 6.8	+ 6.4
ι Draconis	49.5	59 50 54.3	− 3.3	+ 6.0
γ Cassiopeæ	50.3	59 21 17.8	− 5.4	+ 5.9
θ Draconis	49.6	59 14 17.7	− 9.7	+ 5.9
δ Cassiopeæ	50.3	58 55 27.2	− 5.3	+ 5.8
δ Urs. mj	49.4	58 25 19.5	− 8.1	+ 5.6
β Cassiopeæ	50.6	57 46 7.1	− 5.6	+ 5.5
β Urs. mj	49.3	57 42 52.1	− 4.1	+ 5.5
ε Urs. mj	49.4	57 19 15.4	− 6.2	+ 5.4
ζ Urs. mj	49.4	56 14 12.9	− 3.5	+ 5.1
α Cassiopeæ	50.3	55 9 37.8	− 6.3	+ 4.8
γ Urs. mj	49.4	55 5 2.0	− 2.3	+ 4.8
θ Urs. mj	49.4	52 47 50.2	− 3.9	+ 4.2
γ Persei	50.1	52 30 14.4	− 2.5	+ 4.2
β Draconis	49.5	52 29 45.1	− 3.5	+ 4.1
γ Draconis	49.6	51 31 37.0	− 7.6	+ 3.9
η Urs. mj	49.4	50 34 6.3	− 4.0	+ 3.6
ι Urs. mj	49.3	49 0 0.6	− 6.7	+ 3.2
α Persei	50.1	48 56 46.8	− 3.9	+ 3.2
κ Urs. mj	49.3	48 7 22.3	− 5.5	+ 3.0
δ Persei	50.1	46 57 39.4	− 5.3	+ 2.6
α Aurigæ	50.0	45 42 40.1	+ 1.9	+ 2.3
β Aurigæ	50.0	44 53 15.6	− 6.7	+ 2.1
δ Cygni	49.7	44 31 59.3	− 3.8	+ 2.0
α Cygni	50.1	44 23 52.5	− 2.1	+ 2.0
β Boötis	49.4	41 23 15.5	− 6.5	+ 1.1
ο Andromedæ	50.6	40 59 13.0	− 3.1	+ 0.9
β Persei	50.3	39 58 17.2	+ 0.3	+ 0.7
12 Can. Ven	49.4	39 40 25.1	− 0.3	+ 0.6
γ Cygni	49.7	39 28 13.3	+ 5.3	+ 0.5
γ Boötis	49.4	39 24 48.9	+ 1.5	+ 0.5
η Herculis	49.5	39 24 46.6	+ 3.7	+ 0.5
ε Persei	50.4	+39 15 40.9	− 0.8	+ 0.5
α Lyræ	50.0	38 33 58.9	0.0	+ 0.3
θ Herculis	49.8	37 17 55.1	+ 1.3	0.0
θ Aurigæ	50.2	37 9 50.6	− 5.4	0.0
δ Lyræ	49.6	36 35 49.6	+ 4.5	− 0.2
δ Boötis	49.4	34 15 41.4	+ 2.6	− 0.8
β Androm	50.2	34 17 17.7	+ 3.9	− 0.8
β Tria. bor	50.1	33 47 29.3	+ 2.3	− 0.9
β Lyræ	49.6	33 5 25.3	+ 4.6	− 1.1
ε Cygni	50.0	33 2 52.0	+ 0.1	− 1.1
γ Tria. bor	50.1	32 40 37.3	+ 4.1	− 1.2
α Geminorum	50.0	32 24 34.0	+ 2.9	− 1.3
γ Lyræ	49.7	32 21 51.5	+ 5.1	− 1.4
ζ Herculis	49.9	32 4 18.8	+ 3.8	− 1.4
ε Herculis	49.8	31 18 44.3	+ 5.8	− 1.6
ζ Persei	50.3	31 7 3.7	− 2.1	− 1.6
δ Androm	50.6	29 29 21.3	− 0.4	− 2.0
ζ Cygni	50.3	29 12 52.7	+ 1.2	− 2.1
η Pegasi	50.4	28 55 16.8	+ 1.8	− 2.2
β Geminorum	49.8	28 36 21.5	+ 2.3	− 2.3
β Tauri b	49.8	28 22 7.2	+ 0.9	− 2.4
α Tria. bor	50.6	28 21 1.2	+ 5.8	− 2.4
39 Ariet	50.7	28 11 32.7	+ 5.1	− 2.4
ε Boötis	49.5	28 8 31.1	+ 1.1	− 2.5
μ Herculis	49.6	27 53 7.2	+ 8.5	− 2.5
α Androm	50.2	27 42 34.5	+ 2.2	− 2.5
μ Cygni	50.6	27 37 28.1	+ 1.5	− 2.6
α Coron. bor	49.5	27 34 20.8	+ 5.6	− 2.6
β Cygni	49.7	27 27 11.5	+ 7.3	− 2.6
μ Leonis	49.6	27 10 11.6	− 3.0	− 2.7
β Pegasi	50.6	26 43 55.3	− 0.1	− 2.8
41 Arietis	50.1	26 12 46.9	+ 1.4	− 3.0
ε Geminorum	49.2	25 21 1.9	− 2.4	− 3.2
δ Herculis	49.7	25 9 8.5	+ 2.4	− 3.3
ε Leonis	49.6	24 54 38.1	− 2.5	− 3.3
ζ Leonis	49.3	24 39 7.5	+ 3.4	− 3.4
η Tauri	50.4	23 18 40.3	+ 3.2	− 3.7

III*a*.

SECTOR AT PARIS, WITH ATTACHED TELESCOPE. Corr'n = + 15″.0 sin δ − 12″.6 cos δ.

Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.
Polaris	50.6	+87 57 48.3	−14.3	+14.5
γ Cephei	50.6	76 14 2.5	−16.3	+11.6
γ Cassiopeæ	50.6	59 21 21.2	− 2.0	+ 6.5
δ Cassiopeæ	50.6	58 55 27.8	− 4.6	+ 6.3
α Persei	50.6	48 56 49.5	− 1.2	+ 3.0
α Lyræ	50.6	38 33 56.7	− 2.3	− 0.4
δ Andromedæ	50.6	29 29 23.4	+ 1.7	− 3.5
α Arietis	50.6	22 16 11.1	+ 9.6	− 5.5
β Herculis	50.5	22 3 9.7	+ 2.5	− 5.6
Arcturus	50.5	20 29 41.7	+10.3	− 6.2
γ Herculis	50.5	19 45 32.6	+ 4.2	− 6.5
β Arietis	50.7	19 34 35.3	+ 8.1	− 6.6
ε Pegasi	50.6	18 44 57.0	+ 4.8	− 6.9
ε Tauri	50.7	18 36 16.2	+10.6	− 7.0
α Sagittarii	50.7	17 27 32.1	+ 7.9	− 7.3
γ Serpentis	50.5	16 29 47.5	+11.8	− 7.6
α Tauri	50.7	+15 59 10.1	+15.0	− 7.8
γ Delphini	50.7	15 14 26.1	+ 7.6	− 8.1
α Delphini	50.7	15 2 55.2	+10.5	− 8.2
γ Tauri	50.7	15 0 12.4	+ 9.2	− 8.2
ε Aquilæ	50.7	14 45 0.6	+ 3.9	− 8.3
α Herculis	50.6	14 41 48.6	+ 5.5	− 8.3
δ Delphini	50.7	14 11 40.6	+ 4.0	− 8.5
α Pegasi	50.7	13 51 59.3	+ 5.5	− 8.7
ζ Delphini	50.7	13 49 55.6	+14.2	− 8.7
γ Pegasi	50.6	13 47 40.3	+ 6.5	− 8.7
β Delphini	50.6	13 44 36.1	+ 5.8	− 8.7
ζ Aquilæ	50.7	13 30 47.2	+ 7.5	− 8.8
α Ophiuchi	50.6	12 45 52.5	+ 9.3	− 9.1
δ Serpentis	50.5	11 23 34.9	+ 7.2	− 9.4
ε Delphini	50.6	10 38 24.8	+10.8	− 9.6
γ Aquilæ	50.7	10 1 30.4	+ 7.2	− 9.8

Declinations—Continued.

IIIa.

SECTOR AT PARIS, WITH ATTACHED TELESCOPE. Corr'n = + 15″.0 sin δ − 12″.6 cos δ.

	Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.		Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.
			° ′ ″	″	″				° ′ ″	″	″
ζ	Pegasi	50.6	+ 9 32 8.1	+ 7.5	−10.0	α	Equulei	50.6	+ 4 13 54.8	....	−11.4
ε	Pegasi	50.5	8 44 36.1	+ 7.9	−10.2	θ′	Serpentis	50.7	3 54 12.8	+17.1	−11.5
α	Aquilæ	50.6	8 13 49.9	+ 8.1	−10.3	α	Ceti	50.7	3 5 50.5	+15.5	−11.7
α	Serpentis	50.5	7 13 55.7	+ 6.8	−10.7	δ	Aquilæ	50.7	2 38 31.4	+17.5	−11.9
β	Aquilæ	50.7	5 48 21.1	+17.8	−11.0	γ	Ophiuchi	50.6	2 49 37.5	+11.5	−11.8
ε	Serpentis	50.5	5 15 2.9	+ 6.7	−11.2	γ	Ceti	50.7	2 10 19.5	+15.9	−12.0
β	Ophiuchi	50.6	4 41 44.5	+ 6.8	−11.2						

IV.

SEXTANT AT THE CAPE (PRINCIPAL TELESCOPE). Corr'n + 6″.9 sin δ + 3″.4 cos δ.

	Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.		Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.
μ	Herculis	52.6	Γ+27 52 54.4	− 4.3	+ 6.3	δ	Virginis	52.2	4 45 41.3	− 1.4	+ 4.1
δ	Herculis	52.6	Γ25 8 55.3	− 9.9	+ 6.0	β	Ophiuchi	52.6	4 41 34.9	− 2.8	+ 4.0
μ	Geminorum	52.1	22 36 47.6	− 6.0	+ 5.8	β	Virginis	52.4	3 10 16.4	− 4.3	+ 3.8
η	Geminorum	52.1	22 33 3.6	− 4.4	+ 5.8	α	Ceti	52.1	3 5 27.6	− 7.4	+ 3.8
δ	Geminorum	52.1	22 24 57.1	− 4.8	+ 5.7	γ	Ophiuchi	52.6	2 49 22.8	− 3.2	+ 3.8
γ	Cancri	52.3	22 20 47.7	+ 0.8	+ 5.7	δ	Aquilæ	51.7	2 38 5.6	− 8.3	+ 3.8
α	Arietis	51.5	Γ22 15 55.0	− 6.5	+ 5.7	γ	Ceti	52.0	2 9 58.3	− 5.3	+ 3.7
β	Herculis	51.4	Γ22 3 7.2	0.0	+ 5.7	η	Virginis	52.3	0 43 27.6	....	+ 3.5
δ	Leonis	53.0	21 53 16.3	− 3.2	+ 5.7	ζ	Virginis	52.2	0 41 21.0	− 5.8	+ 3.5
γ	Leonis	52.3	21 5 38.9	− 2.9	+ 5.6	η	Antinoi	51.8	0 22 59.5	− 7.1	+ 3.5
ζ	Tauri	52.1	20 57 42.5	− 6.7	+ 5.6	γ	Virginis	52.2	− 0 4 28.0	− 2.0	+ 3.4
ζ	Geminorum	52.1	20 54 34.9	− 6.8	+ 5.6	δ	Orionis	52.0	− 0 30 25.3	− 2.9	+ 3.3
α	Boötis	52.4	20 29 32.4	+ 1.0	+ 5.6	δ	Ceti	52.0	− 0 45 53.1	− 3.4	+ 3.3
η	Boötis	52.3	19 39 35.4	− 2.3	+ 5.5	ε	Orionis	52.1	− 1 23 9.7	− 7.0	+ 3.2
β	Arietis	52.2	19 34 24.3	− 2.9	+ 5.5	α	Aquarii	51.8	− 1 31 31.8	− 8.1	+ 3.2
δ	Cancri	52.4	19 3 14.0	+ 0.6	+ 5.5	θ	Antinoi	51.8	− 1 32 42.2	− 6.8	+ 3.2
ε	Tauri	52.3	18 36 4.5	− 1.1	+ 5.4	ι	Antinoi	51.7	− 1 49 17.0	− 5.5	+ 3.1
γ	Arietis	52.0	18 3 24.7	....	+ 5.3	ζ	Orionis	52.0	− 2 5 56.8	− 6.2	+ 3.1
η	Leonis	52.7	17 58 8.4	− 3.8	+ 5.3	γ	Aquarii	51.8	− 2 38 19.0	− 3.7	+ 3.0
δ′	Tauri	52.1	16 55 55.1	− 2.6	+ 5.3	μ	Serpentis	52.6	− 2 38 45.9	− 1.6	+ 3.0
θ	Leonis	52.2	16 47 23.4	− 3.1	+ 5.3	η	Orionis	52.1	− 2 39 3.3	− 6.9	+ 3.0
γ	Geminorum	52.2	16 35 6.5	− 6.3	+ 5.3	η	Serpentis	51.7	− 2 56 35.2	− 3.4	+ 3.0
γ	Serpentis	52.6	16 29 34.5	− 1.2	+ 5.2	δ	Ophiuchi	52.8	− 3 1 51.9	− 2.1	+ 3.0
β	Serpentis	52.6	16 13 5.9	− 8.9	+ 5.2	ζ	Serpentis	52.8	− 3 39 0.7	− 0.8	+ 3.0
α	Tauri	52.0	15 58 50.3	− 4.8	+ 5.1	ε	Ophiuchi	52.6	− 4 3 41.2	+ 0.8	+ 2.8
β	Leonis	52.4	15 57 57.9	− 6.6	+ 5.1	ο	Ceti	52.3	− 4 7 34.3	− 0.3	+ 2.8
γ	Tauri	52.3	14 59 57.0	− 6.2	+ 5.1	θ	Virginis	52.3	− 4 11 51.1	− 0.5	+ 2.8
ζ	Boötis	52.6	14 48 43.4	− 7.7	+ 5.1	λ	Antinoi	51.7	− 5 14 10.9	− 4.4	+ 2.7
α	Herculis	52.6	14 41 34.2	− 8.9	+ 5.1	β	Eridani	52.1	− 5 25 54.4	− 1.3	+ 2.7
α	Pegasi	51.8	Γ13 51 51.0	− 2.8	+ 5.0	ι	Orionis	52.1	− 6 5 48.9	− 5.1	+ 2.6
γ	Pegasi	52.2	13 47 25.6	− 8.2	+ 5.0	β	Aquarii	51.9	− 6 39 26.5	− 1.7	+ 2.5
α	Leonis	52.4	13 10 36 3	− 3.2	+ 4.9	φ	Aquarii	51.8	− 7 23 36.2	− 3.7	+ 2.4
α	Cancri	52.4	12 48 26.0	....	+ 4.9	ο	Eridani	52.0	− 7 30 30.6	− 0.2	+ 2.4
α	Ophiuchi	52.6	12 45 38.4	− 4.8	+ 4.9	α	Hydræ	52.5	− 7 35 17.9	+ 1.3	+ 2.4
ε	Virginis	52.3	12 18 25.3	− 6.3	+ 4.8	β	Libræ	52.6	− 8 26 34.7	− 2.1	+ 2.3
δ	Serpentis	52.6	11 23 23.4	− 4.3	+ 4.7		Rigel	52.0	− 8 30 41.8	− 1.0	+ 2.3
ο	Leonis	52.3	11 0 49.1	− 7.6	+ 4.7	λ	Aquarii	51.8	− 8 54 15.1	− 5.5	+ 2.2
ρ	Leonis	52.2	10 34 59.3	− 5.1	+ 4.7	26	Monocerotis	52.2	− 8 59 13.5	+ 1.2	+ 2.2
γ	Aquilæ	51.9	10 1 12.0	−11.2	+ 4.6	κ	Virginis	52.4	− 9 5 47.2	− 7.7	+ 2.2
β	Cancri	52.2	9 55 58.8	− 9.9	+ 4.6	θ	Ceti	52.2	− 9 28 54.0	− 0.2	+ 2.2
β	Can. min	52.4	8 46 11.7	− 2.5	+ 4.5	ζ	Eridani	52.0	− 9 45 56.0	−25.6	+ 2.1
ε	Pegasi	51.8	8 44 20.8	− 7.4	+ 4.5	κ	Orionis	52.1	− 9 46 45.0	+ 0.7	+ 2.1
α	Aquilæ	52.1	8 13 36.0	− 5.8	+ 4.4	α	Virginis	52.3	− 9 50 54.7	− 2.3	+ 2.1
α	Orionis	52.2	7 20 3.7	− 6.6	+ 4.3	ε	Eridani	52.0	−10 19 15.8	− 4.8	+ 2.1
α	Serpentis	52.6	7 13 43.6	− 5.3	+ 4.3	δ	Eridani	52.0	−10 37 35.6	− 2.3	+ 2.0
γ	Orionis	52.0	6 5 48.3	−10.6	+ 4.2	η	Ceti	51.9	−11 30 52.4	− 1.8	+ 2.0
	Procyon	52.2	5 50 35.0	− 1.2	+ 4.2	α	Libræ	52.4	−14 59 8.2	+ 3.3	+ 1.5
β	Aquilæ	51.9	5 48 1.3	− 2.0	+ 4.1	λ	Can. mj	52.3	−15 16 57.6	+ 2.5	+ 1.5
ε	Serpentis	52.6	5 14 49.3	− 6.9	+ 4.1	β	Capricorni	51.8	−15 33 0.9	+ 1.3	+ 1.4

Declinations—Continued.

IV.

SEXTANT AT THE CAPE (PRINCIPAL TELESCOPE). Corr'n+6″.9 sin δ+3″.4 cos δ.

Name.	Time of observation.	Mean declination 1750.0.	= Bradley.	Correction.	Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.
		° ′ ″	″	″			° ′ ″	″	″
Sirius	52.1	−16 23 36.9	+ 2.0	+ 1.3	α Hydr. med	52.5	−27 53 45.2	....	− 0.2
β Scorpii	52.6	−19 5 54.4	− 0.5	+ 0.9	κ *Centaur*	52.5	−31 44 34.2	− 5.7	− 0.7
β Lepor	52.0	−20 58 42.1	− 2.3	+ 0.7	g *Centaur*	52.5	−33 11 28.4	− 9.2	− 0.9
ε Corvi	52.5	−21 13 45.2	− 3.8	+ 0.6	δ Columbæ	52.1	−33 19 36.6	....	− 0.9
π Sagittarii	51.8	−21 23 50.8	− 6.9	+ 0.6	ε Scorpii	52 6	−33 48 41.8	− 3.6	− 0.9
α Scorpii	52.4	−25 51 12.2	− 6.2	0.0					

COMPARED WITH LA CAILLE IN HIS "ASTRONOMIÆ FUNDAMENTA."

Name.	Time of observation.	Mean declination, 1750.0.	= La Caille.	Correction.	Name.	Time of observation.	Mean declination, 1750.0.	= La Caille.	Correction.
		° ′ ″	″	″			° ′ ″	″	″
α *Columbæ*	52.5	−34 13 23.1	− 1.9	− 1.1	η Pavonis	52.2	−64 33 23.8	+ 2.4	− 4.9
ξ *Eridani*	52.0	−34 25 25.2	− 0.8	− 1.1	α Pisc. vol	52.3	−65 24 6.0	+ 2.8	− 4.9
ε *Sagittarii*	52.2	−34.28 18.7	− 2.8	− 1.1	ζ Tucanæ	52.2	−66 20 40.9	+ 1.7	− 5.0
ι *Centauri*	52.3	−35 23 7.1	− 1.9	− 1.1	γ Pavonis	52.2	−66 28 13.1	+ 1.7	− 5.1
β *Columbæ*	52.5	−35 52 41.6	− 2.3	− 1.1	β Muscæ	52.3	−66 44 1.4	+ 2.8	− 5.1
δ Cœli	52.0	−45 30 9.4	+ 0.1	− 2.5	β Pavonis	52.0	−67 4 2.9	+ 2.6	− 5.1
λ Phœnicis	52.1	−50 11 19.5	− 0.8	− 3.1	δ Pisc. vol	52.3	−67 29 53.2	+ 3.0	− 5.2
ρ Centauri	52.4	−50 58 32.5	+ 0.6	− 3.2	γ Tria. austr	52.5	−67 43 27.8	+ 2.3	− 5.2
Canopus	52.2	−52 34 7.8	− 3.2	− 3.3	α Muscæ	52.4	−67 45 11.3	+ 3.9	− 5.2
χ Eridani	52.3	−52 51 43.2	− 0.3	− 3.3	α Tria. austr	52.5	−68 31 20.0	+ 2.5	− 5.3
φ Argûs	52.3	−53 23 11.6	+ 0.9	− 3.4	β Argûs	52.3	−68 41 21.0	+ 3.7	− 5.3
ζ Aræ	52.2	−55 33 33.7	− 2.7	− 3.7	ν Doradûs	52.1	−68 47 10.2	+ 3.5	− 5.3
γ Crucis	52.3	−55 42 42.0	+ 0.7	− 3.8	ω Argûs	52.3	−68 48 1.1	+ 3.6	− 5.3
γ Aræ	52.5	−56 6 18.3	+ 0.2	− 3.8	δ Hydri	52.0	−69 48 0.5	+ 5.5	− 5.4
ζ Phœnicis	51.9	−56 35 15.3	....	− 3.9	δ Muscæ	52.4	−70 11 32.3	+ 3.4	− 5.4
δ Crucis	52.3	−57 21 27.1	+ 1.1	− 4.0	γ Muscæ	52.3	−70 44 49.0	+ 3.8	− 5.4
ξ Phœnicis	52.2	−57 52 54.3	....	− 4.0	G Argûs	52.3	−71 35 44.3	*+ 3.8	− 5.5
ι Argûs	52.4	−58 14 5.3	+ 1.7	− 4.1	T Argûs	52.3	−72 45 41.7	+ 5.4	− 5.6
β Crucis	52.4	−58 19 5.0	+ 1.3	− 4.1	λ Chamæleonis	52.4	−73 58 30.5	+ 4.3	− 5.7
η Argûs	52.3	−58 22 36.1	+ 1.6	− 4.1	π Chamæleonis	52.4	−74 30 44.8	+ 4.4	− 5.8
α Eridani	52.2	−58 30 49.3	+ 1 2	− 4.2	κ Hydri	52.0	−74 46 39.2	+ 8.0	− 5.8
ε Argûs	52.2	−58 42 48.6	+ 2.3	− 4.2	γ Hydri	52.0	−74 59 49.4	+ 5.0	− 5.8
ε Crucis	52.4	−59 1 9.8	+ 0.2	− 4.2	κ Chamæleonis	52.4	−75 7 41.3†	+ 4.7	− 5.8
β Centauri	52.5	−59 8 58.6	+ 1.4	− 4.2	α Chamæleonis	52.3	−76 7 7.6	+ 4.5	− 5.9
β Indi	51.8	−59 22 16.0	+ 1.6	− 4.3	λ Hydri	51.9	−76 17 11.7	+ 5.5	− 5.9
γ Tucanæ	52.1	−59 35 57.1	+ 1.0	− 4.3	β Chamæleonis	52.4	−77 55 13.2	+ 5.2	− 6.1
α^2 Centauri	52.5	−59 47 6.2	+ 1.3	− 4.3	ν Octantis	51.8	−78 27 55.8	....	− 6.2
α^1 Centauri	52.5	−59 47 22.4	+ 1.3	− 4.3	β Hydri	52.1	−78 39 43.6	+ 4.6	− 6.2
p Argûs	52.3	−60 24 18.7	+ 1.9	− 4.3	δ Chamæleonis	52.3	−79 13 16.2	+ 5.7	− 6.3
δ Aræ	52.5	−60 26 0.8	+ 1.5	− 4.3	μ Hydri	52.0	−80 11 31.6	+10.4	− 6.3
α Tucanæ	52.0	−61 29 31.3	+ 1.2	− 4.4	δ Montis mensæ	52.0	−80 46 8.3	+ 6.6	− 6.3
λ Centauri	52.1	−61 38 17.2	+ 2.3	− 4.4	δ Octantis	52.5	−82 29 5.0	+ 4.7	− 6.5
α Equulei	52.2	−61 40 36.6	+ 2.0	− 4.5	β Octantis	52.1	−82 40 22.0	+ 4.4	− 6.5
α Crucis	52.3	−61 42 43.6	+ 1.8	− 4.5	η Octantis	52.4	−83 14 44.1	+ 6.4	− 6.5
β Tria. austr	52.5	−62 37 30.6	+ 1.4	− 4.6	γ Octantis	52.5	−83 24 21.5	+ 3.5	− 6.5
β Doradûs	52.1	−62 39 25.6	+ 2.4	− 4.6	ζ Octantis	52.3	−84 37 17.4	+ 7.9	− 6.6
α Hydri	52.3	−62 47 32.2	+ 2.1	− 4.6	τ Octantis	51.8	−88 49 49.8	....	− 6.8
θ Argûs	52.2	−63 5 20.5	+ 2.3	− 4.7	τ Octantis S. P	52.4	−91 9 56.1	....	− 7.0
α Reticuli	52.0	−63 6 10.1	+ 2.9	− 4.7	ζ Octantis S. P	52.4	−95 22 24.7	+10.0	− 7.2
α Circini	52.5	−63 51 43.8	+ 2.1	− 4.8	β Octantis S. P	52.4	− 97 19 32.3	+ 1.3	− 7.3
ν Argûs	52.4	−63 55 2.5	+ 2.7	− 4.8	δ Octantis S. P	52.5	−97 30 37.7	+12.6	− 7.3

* La Caille is correct from page 195; the declination in Catalogue is erroneous by 36″.

† Error of a′ in La Caille's catalogue.

Declinations—Continued.

IV*a*.

SEXTANT AT THE CAPE WITH ATTACHED TELESCOPE. CORR'N = + 8''.33 SIN δ + 4''.45 COS δ.

	Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.		Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.
			° ′ ″	″	″				° ′ ″	″	″
γ	Persei	51.9	+52 30 9.2	− 7.7	+ 9.3	α	Aquilæ	51.8	+ 8 13 36.8	− 5.0	+ 5.6
β	Draconis	51.6	52 29 37.0	−11.6	+ 9.3	γ	Orionis	52.1	6 5 53.8	− 5.1	+ 5.3
γ	Draconis	51.6	51 31 40.7	− 3.9	+ 9.3		Procyon	52.3	5 50 36.8	− 0.6	+ 5.3
η	Urs. Mj	51.5	50 34 10.3	0.0	+ 9.3	δ	Virginis	51.8	4 45 32.7	−10.0	+ 5.1
α	Persei	52.0	48 56 38.0	−12.7	+ 9.2	α	Ceti	51.8	3 5 23.6	−11.4	+ 4.9
δ	Persei	52.0	46 57 34.8	− 9.9	+ 9.1	γ	Ophiuchi	51.6	2 49 17.8	− 8.2	+ 4.8
α	Aurigæ	52.0	45 42 29.0	− 9.4	+ 9.1	η	Virginis	51.9	0 43 24.5	....	+ 4.6
β	Aurigæ	52.1	44 53 10.5	−11.8	+ 9.0	ζ	Virginis	51.5	+ 0 41 19.5	− 7.3	+ 4.6
δ	Cygni	51.6	⌈44 31 55.5	− 7.6	+ 9.0	δ	Orionis	52.1	− 0 30 32.1	− 9.7	+ 4.5
α	Cygni	51.6	44 23 44.0	−10.6	+ 9.0	δ	Ceti	51.6	0 46 0.9	−11.2	+ 4.2
β	Boötis	51.5	41 23 12.4	− 9.6	+ 8.8	ε	Orionis	52.1	1 23 4.2	− 1.5	+ 4.2
γ	Andromedæ	51.8	41 6 43.2	−16.1	+ 8.8	ζ	Orionis	52.1	2 5 51.1	− 0.5	+ 4.1
o	Andromedæ	51.8	40 59 2.6	−13.5	+ 8.8	δ	Ophiuchi	51.6	3 1 51.5	− 1.7	+ 4.0
β	Persei	52.0	⌈39 58 11.0	− 5.9	+ 8.8	ε	Ophiuchi	51.6	4 3 41.5	+ 0.5	+ 3.8
12	Can. ven	51.5	39 40 18.0	− 7.4	+ 8.7	o	Ceti	51.6	4 7 34.1	− 9.1	+ 3.8
γ	Cygni	51.7	39 28 0.3	− 7.7	+ 8.7	θ	Virginis	51.6	− 4 11 53.1	− 2.5	+ 3.8
γ	Boötis	51.5	39 24 41.2	− 6.2	+ 8.7						
ε	Persei	52.0	39 15 26.6	−15.1	+ 8.7		Compared with the corrected values from I 4.) : = P ± . . . P.				
α	Lyræ	51.6	38 33 51.2	− 7.8	+ 8.7						
θ	Herculis	51.6	37 17 42.6	−11.2	+ 8.6	β¹	Tucanæ	51.6	− 64 20 17.9	....	− 5.6
δ	Lyræ	51.6	⌈36 35 39.5	− 5.6	+ 8.5	β	Reticuli	52.0	65 35 54.4	....	− 5.8
ε	Cygni	51.6	33 2 48.6	− 3.3	+ 8.3	ζ	Tucanæ	51.5	66 20 41.7	+ 4.2	− 5.9
θ	Leonis	51.7	16 47 23.5	− 3.0	+ 6.7	δ	Pavonis	51.7	66 46 43.5	....	− 6.0
γ	Geminorum	52.2	16 35 8.5	− 4.3	+ 6.6	δ	Hydri	52.0	69 48 3.1	+ 2.8	− 6.3
β	Serpentis	51.6	16 13 8.6	− 6.2	+ 6.6	ζ	Pavonis	51.7	71 35 14.6	....	− 6.5
α	Tauri	52.1	15 58 53.5	− 1.6	+ 6.5	ε	Pavonis	51.7	73 31 19.8	....	− 6.7
β	Leonis	51.7	15 57 59.7	− 4.8	+ 6.5	κ	Hydri	52.0	74 46 45.2	(− 0.2)	− 6.9
ζ	Boötis	51.6	14 48 44.1	− 7.0	+ 6.4	ε	Chamæleontis	51.5	76 49 38.7	....	− 7.1
α	Herculis	52.6	14 41 37.4	− 5.7	+ 6.4	β	Hydri	51.7	75 39 43.1	+ 6.7	− 7.2
γ	Pegasi	51.8	13 47 24.2	− 9.6	+ 6.2	μ	Hydri	52.0	80 11 37.8	(+ 0.1)	− 7.4
α	Leonis	52.2	13 10 33.5	− 6.0	+ 6.2	δ	Octantis	51.8	82 29 4.1	+ 7.4	− 7.7
ε	Virginis	51.8	12 18 26.2	− 5.4	+ 6.1	δ	Octantis S. P.	52.0	97 30 43.0	+ 2.0	− 8.8
ρ	Leonis	51.8	+ 10 34 58.8	− 5.6	+ 5.9	β	Hydri S. P.	51.7	−101 19 55.5	+14.7	− 9.0

IV*b*.

SECTOR AT THE CAPE. CORR'N = + 20''.5 SIN δ + 11''.5 COS δ.

	Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.		Name.	Time of observation.	Mean declination, 1750.0.	= Bradley.	Correction.
α	Virginis	51.5	− 9 50 58.1	− 5.8	+ 7.8	β	Ceti	51.7	−19 21 51.8	− 6.0	+ 4.1
ζ	Ophiuchi	51.6	10 2 19.5	− 3.7	+ 7.7	54	Eridani	52.1	20 10 19.2	− 8.2	+ 3.7
λ	Virginis	51.5	12 12 26.8	− 3.4	+ 6.8	δ	Leporis	52.1	20 55 16.4	− 4.3	+ 3.3
ε	Ceti	51.7	12 56 55.4	− 4.9	+ 6.6	β	Leporis	52.1	20 58 45.1	− 5.3	+ 3.3
α	Capricorni	51.8	13 18 5.4	− 9.4	+ 6.5	μ	Sagittarii	51.5	21 5 58.1	− 8.9	+ 3.3
γ	Libræ	51.6	13 56 13.3	− 4.2	+ 6.2	π	Sagittarii	51.6	21 23 48.7	− 4.8	+ 3.2
γ	Eridani	52.0	14 14 24.1	− 8.0	+ 6.1	γ	Hydræ	51.7	21 50 44.4	− 1.7	+ 3.1
53	Eridani	52.1	14 48 46.8	− 4.3	+ 5.9	δ	Scorpii	51.5	21 53 18.4	− 3.4	+ 3.0
α	Libræ	51.5	14 59 16.5	− 5.0	+ 5.8	β	Corvi	51.7	22 0 40.4	− 1.7	+ 3.0
δ	Corvi	51.6	15 7 20.5	− 6.7	+ 5.8	o	Sagittarii	51.7	22 5 2.7	− 9.1	+ 2.9
η	Ophiuchi	51.5	15 23 30.9	− 5.7	+ 5.7	γ	Leporis	52.2	22 32 59.3	− 3.7	+ 2.7
β	Capricorni	51.8	15 33 8.0	− 5.8	+ 5.6	α	Corvi	52.2	23 20 6.1	− 5.8	+ 2.4
γ	Corvi	51.7	16 8 14.3	− 5.9	+ 5.4	ρ	Argûs	52.3	23 36 7.9	− 6.8	+ 2.3
	Sirius	52.0	16 23 41.5	− 2.6	+ 5.2	ξ	Argûs	52.2	24 15 4.5	− 5.2	+ 2.0
α	Crateris	51.7	16 58 30.2	− 6.5	+ 5.0	γ	Scorpii	51.6	24 16 53.8	− 1.7	+ 2.0
δ	Aquarii	51.8	17 8 39.9	− 1.8	+ 5.0	θ	Ophiuchi	51.5	24 43 21.1	− 0.8	+ 1.8
δ	Capricorni	51.8	17 14 58.6	− 3.6	+ 4.9	σ	Scorpii	51.5	24 58 3.3	+ 4.4	+ 1.7
γ	Capricorni	51.8	17 46 43.6	− 6.1	+ 4.7	l	Eridani	52.0	25 22 11.1	− 6.8	+ 1.6
β	Can. Mj	52.0	17 51 13.3	− 8.1	+ 4.6	π	Scorpii	51.6	25 22 18.1	− 4.1	+ 1.6
α	Leporis	52.1	18 1 20.9	− 5.2	+ 4.6	λ	Sagittarii	51.6	25 31 58.5	− 5.9	+ 1.5
γ	Scorpii	51.8	18 47 21.7	− 4.7	+ 4.3	α	Scorpii	51.5	25 51 8.8	− 2.8	+ 1.4
β	Scorpii	51.8	−19 5 59.9	− 5.1	+ 4.2	δ	Can. Mj	52.2	−26 0 56.5	− 5.9	+ 1.3

Declinations—Continued.

IV*b*.

SECTOR AT THE CAPE. CORR.: $+ 20''.5 \sin\delta + 11''.5 \cos\delta$—Continued.

Name.	Time of observation.	Mean declination, 1750.0.	=Bradley.	Correction.	Name.	Time of observation.	Mean declination, 1750.0.	=Bradley.	Correction.
		° ′ ″	″	″			° ′ ″	″	″
σ Sagittarii	51.6	−26 34 51.8	− 7.8	+ 1.1	δ Sagittarii	51.6	− 29 54 18.3	− 0.3	− 0.3
φ Sagittarii	51.6	27 13 13.3	− 4.4	+ 0.8	ζ Can. Mj	52.2	29 58 11.8	− 3.5	− 0.3
b Can. Mj	52.2	27 35 45.7	− 9.2	+ 0.7	α Fornacis	52.0	29 59 13.4	− 4.9	− 0.3
τ Scorpii	51.6	27 40 14.9	+ 2.2	+ 0.6	ζ Sagittarii	51.6	30 12 35.8	− 5.0	− 0.4
τ Sagittarii	51.6	28 0 34.6	− 4.1	+ 0.5	γ^2 Sagittarii	51.6	30 23 53.7	− 5.0	− 0.5
ρ Scorpii	51.5	28 27 35.7	+ 1.8	+ 0.3	ξ Hydræ	51.7	30 28 35.6	+ 1.9	− 0.5
ε Can. Mj	52.2	28 39 0.1	− 4.1	+ 0.2	α Pisc. austr	51.8	30 56 24.1	+ 0.6	− 0.7
η Can. Mj	52.2	28 49 59.4	+15.7	+ 0.1	υ Eridani	52.0	31 5 25.7	− 0.7	− 0.8
γ^1 Sagittarii	51.6	−29 33 45.7	....	− 0.1	ε Scorpii	51.5	−33 48 38.5	− 0.3	− 1.9

IV*b*.

SECTOR AT THE CAPE (continued). COMPARED WITH LA CAILLE IN HIS "FUNDAMENTA."

Name.	Time of observation.	Mean declination, 1750.0.	=La Caille.	Correction.	Name.	Time of observation.	Mean declination, 1750.0.	=La Caille.	Correction.
		° ′ ″	″	″			° ′ ″	″	″
θ Centauri	51.6	−35 7 35.6	− 2.4	− 2.4	ε Lupi	51.6	−43 45 56.1	− 0.8	− 5.9
ι Centauri	51.5	35 23 9.6	− 4.4	− 2.6	γ Phœnicis	51.7	44 36 22.1	− 4.0	− 6.2
π Argûs	52.2	36 39 45.5	− 1.9	− 3.1	ι Lupi	51.5	44 53 28.4	−15.7	− 6.4
β Telescopii	51.6	36 48 23.6	− 1.9	− 3.1	β^1 Sagittarii	51.7	44 53 43.1	− 0.7	− 6.4
λ Scorpii	51.6	36 53 29.9	− 1.9	− 3.2	β^2 Sagittarii	51.7	45 14 13.5	− 0.2	− 6.5
υ Scorpii	51.6	37 3 57.3	− 1.9	− 3.2	ζ Centauri	51.5	46 2 38.7	− 0.9	− 6.8
μ Scorpii	51.6	37 35 20.2	− 2.3	− 3.4	π Lupi	51.5	46 2 58.4	− 0.7	− 6.8
f Eridani	52.0	38 23 55.6	− 1.4	− 3.8	α Telescopii	51.7	46 4 16.2	+ 0.5	− 6.8
γ Gruis	51.8	38 31 28.8	− 0.6	− 3.8	α Lupi	51.5	46 17 40.6	− 0.9	− 6.9
κ Scorpii	51.6	38 52 16.3	− 1.9	− 4.0	γ Argûs	52.2	46 36 35.0	− 0.5	− 7.0
i Argûs	51.3	39 18 40.8	− 1.6	− 4.1	γ Centauri	51.5	47 34 52.6	0.0	− 7.4
δ Lupi	51.5	39 43 10.5	− 1.4	− 4.3	β Phœnicis	51.8	48 3 41.7	− 0.2	− 7.5
α Argûs	52.2	39 56 36.0	− 1.0	− 4.4	μ Argûs	52.3	48 6 17.7	− 1.3	− 7.6
ι Scorpii	51.5	39 59 51.0	− 2.0	− 4.4	α Indi	51.7	48 8 14.9	+ 0.3	− 7.6
γ Lupi	51.5	40 18 6.0	− 1.9	− 4.5	α Gruis	51.8	48 9 22.7	− 0.3	− 7.6
ν Centauri	51.5	40 25 48.4	− 0.4	− 4.6	β Gruis	51.8	48 10 52.0	− 0.3	− 7.6
η Centauri	51.5	41 2 30.5	− 1.4	− 4.8	δ Centauri	51.9	49 19 39.0	0.0	− 8.0
α Sagittarii	51.7	41 3 22.5	− 1.0	− 4.8	α Aræ	51.6	49 38 31.3	− 0.2	− 8.2
κ Centauri	51.5	41 4 46.5	− 1.2	− 4.8	τ Argûs	52.2	50 19 35.8	+ 0.2	− 8.4
μ Centauri	51.5	41 12 59.1	− 1.1	− 4.9	δ Phœnicis	51.7	50 22 41.1	− 1.1	− 8.4
θ Eridani	51.9	41 19 5.4	− 1.0	− 4.9	ο Argûs	52.2	52 2 29.2	− 0.9	− 9.1
ζ Scorpii	51.6	41 54 1.6	− 0.8	− 5.2	ε Centauri	51.5	52 10 53.5	+ 0.6	− 9.1
β Lupi	51.5	42 6 15.0	− 1.2	− 5.2	Canopus	52.1	52 34 1.8	− 2.8	− 9.3
λ Argûs	52.3	42 26 4.9	− 0.8	− 5.4	ε Aræ	51.5	52 44 24.4	− 1.3	− 9.4
θ Scorpii	51.6	42 48 24.4	− 1.2	− 5.5	δ Argûs	52.3	53 48 0.0	+ 0.9	− 9.7
σ Argûs	52.2	42 48 26.1	− 0.6	− 5.5	κ Argûs	52.2	53 56 59.2	+ 1.1	− 9.8
η Scorpii	51.6	42 52 40.1	− 1.7	− 5.6	β Aræ	51.6	55 15 16.1	+ 0.6	−10.3
ν Argûs	52.2	42 59 26.2	− 1.0	− 5.6	ζ Aræ	51.9	55 33 26.9	+ 4.1	−10.4
α Phœnicis	51.8	−43 39 52.8	− 0.4	− 5.9	α Doradas	52.1	−55 34 20.3	− 5.0	−10.4

V.

MEAN DECLINATION FOR 1750.0 (CORRECTED).

C_p...........Sector (Paris)...........W=2.
C'_p...........with telescope attached..W=1.
X_p.... ......Sextant (Paris)...........W=2.
C_c...........Sector (Cape)...........W=2.
X_c...........Sextant.................W=2.
X'_c...........with telescope attached..W=1.

Star.	C_p	C'_p	X_p	X'_c	α	Bradley.	LaCaille.	Magn.	Time. 1700+	W.
	° ′ ″		″		° ′	″	″	m.	a.	
Polaris S. P	+92 1		57.1							
Polaris	87 57	62.8	63.0		10 41	62.6	62.9	2.3	54.9	5
γ Cephei	76 14	14.1			352 19	18.8	14.1	3.4	50.6	1
β Urs. Min.	75 10		36.8		222 56	40.1	36.8	3	55.5	2
γ^2 *Urs. Min*	72 43		25.6		230 20	20.4	25.6	3	55.5	2
β Cephei	69 28 0.3				321 19	4.1	0.3	3.4	50.5	2
δ Draconis	67 13 22.9				288 6	21.3	22.9	3	49.8	2
α *Draconis*	65 34 40.3				209 24	39.9	40.3	3	49.4	2
α Urs. Mj	63 5 41.4				162 1	38.7	41.4	2	41.4	2
ε Cassiopeæ	62 25 26.5				24 10	26.8	26.5	3	50.4	2
η Draconis	62 5 6.4				245 10	7.3	6.4	3.4	49.5	2
α Cephei	61 32 2.3				318 9	2.7	2.3	3	50.0	2
υ Draconis	59 50 60.3				229 51	57.6	60.3	3.4	49.5	2
γ Cassiopeæ	59 21 23.7	27.7			10 27	23.2	25.0	3	50.4	3
θ Draconis	59 14 23.6				239 19	27.4	23.6	3.4	49.6	2
δ Cassiopeæ	58 55 33.0	34.1			17 25	32.4	33.4	3	50.4	3
δ Urs. Mj	58 25 25.1				180 44	27.6	25.1	3	49.4	2
β Cassiopeæ	57 46 12.6				359 0	12.7	12.6	2.3	50.6	2
β Urs. Mj	57 42 57.6				161 38	56.5	57.6	2	49.3	2
ε *Urs. Maj*	57 19 20.8				190 44	21.5	20.8	2	49.4	2
ζ *Urs. Maj*	56 14 18.0				198 27	16.4	18.0	2	49.4	2
α Cassiopeæ	55 9 42.6				6 37	44.1	42.6	3	50.3	2
γ Urs. Mj	55 5 6.8				175 8	4.3	6.8	2	49.4	2
θ *Urs. Maj*	52 47 54.4				139 0	54.1	54.4	3	49.4	2
γ Persei	52 30 18.6			18.5	41 43	16.9	18.6	3	50.7	3
β Draconis	52 29 49.2			46.3	261 12	48.6	48.3	3	49.5	3
γ *Draconis*	51 31 40.9		43.0	50.0	267 22	44.6	43.6	3	52.0	5
η *Urs. Mj*	50 34 9.9		7.4	19.6	204 25	10.3	10.8	2	52.0	5
ι *Urs. Mj*	48 59 63.8		60.0		130 29	67.3	61.9	3	52.9	4
α Persei	48 56 50.0	52.5		47.2	46 39	50.7	49.9	2	50.7	4
κ *Urs. Mj*	48 7 25.3		24.1		131 36	27.8	24.7	3.4	52.8	4
δ Persei	46 57 42.0		45.1	43.6	51 19	44.7	43.6	3	52.9	5
α Aurigæ	45 42 42.4		41.4	38.1	74 34	38.4	41.2	1	52.9	5
β Aurigæ	44 53 17.7			19.5	85 18	22.3	18.3	2.3	50.7	3
δ Cygni	44 32 1.3			4.5	294 17	3.1	2.4	3	50.3	3
α Cygni	44 23 54.5			53.0	308 14	54.6	54.0	2	50.6	3
β Boötis	41 23 16.6			21.2	223 8	22.0	18 1	3	50.1	3
γ Andromedæ	41 6			52.0	27 10	59.3	52.0	2	51.8	1
ε Andromedæ	40 59 14.0			11.4	342 37	16.1	13.1	3.4	51.0	3
β Persei	39 58 17.9			19.8	43 0	16.9	18.5	2	50.9	3
12 Can. ven.	39 40 25.7			26.7	191 4	25.4	26.0	3	50.4	3
γ Cygni	39 28 13.8			9.0	303 19	8.0	12.2	3	50.4	3
γ Boötis	39 24 49.4			49.9	215 30	47.4	49.6	3	50.1	3
η Herculis	39 24 47.1				248 35	42.9	47.1	3.4	49.5	2
ε Persei	39 15 41.4			35.3	55 17	41.7	39.4	3	50.9	3
α Lyræ	38 33 59.2	56.3		59.9	277 7	59.0	58.7	1	50.6	4
θ Herculis	37 17 55.1			51.2	266 55	53.8	53.8	3	50.4	3
θ Aurigæ	37 9 50.6				85 40	56.0	50.6	3	50.2	2
δ Lyræ	36 35 49.4			43.0	281 27	45.1	48.9	3	50.3	3
β Andromedæ	34 17 17.0				13 57	13.8	17.0	2	50.2	2
δ Boötis	34 15 40.6				226 21	38.8	40.6	3	49.4	2
β Tria. bor	33 47 28.4				28 41	27.0	28.4	4	50.1	2
β Lyræ	33 5 24.2				280 13	20.7	24.2	2.3	49.6	2
ε Cygni	33 2 50.9			56.9	309 1	51.9	52.9	3	50.5	3
γ Tria. bor	32 40 36.1				30 38	33.2	36.1	4	50.1	2
α Geminorum	32 24 32.7				109 39	31.1	32.7	1.2	50.0	2
γ Lyræ	32 21 52.9				282 24	46.4	52.9	3	49.7	2
ζ Herculis	+32 4 17.4				247 58	15.2	17.4	3.4	49.9	2

Mean declination for 1750.0 (*corrected*)—Continued.

Star.	C_p	C'_p	X_p	X'_c	α	Bradley.	LaCaille.	Magn.	Time. 1700+	W.
	° ′ ″		″		° ′	″	″	*m.*	*a.*	
ε Herculis	+31 18 42.7	......	......	......	252 41	38.5	42.7	3	49.8	2
ζ Persei	31 7 2.1	......	......	......	54 37	5.8	2.1	3	50.3	2
δ Andromedæ	29 29 19.3	19.5	......	......	6 30	21.7	19.4	3	50.6	3
ζ Cygni	29 12 50.6	......	......	......	315 34	51.5	50.6	3.4	50.3	2
η Pegasi	28 55 14.6	......	......	......	337 50	15.0	14.6	3	50.4	2
β Geminorum	28 36 19.2	......	......	......	112 30	19.2	19.2	2.3	49.8	2
β Tauri	28 22 4.8	......	......	......	77 37	6.3	4.8	2	49.8	2
α Tria. bor.	28 20 58.8	......	......	......	24 43	55.4	58.8	3.4	50.6	2
39 Arietis	+28 11 30.3	......	......	......	38 16	27.6	30.3	4	50.7	2

Star.	C_p	C'_p	X_p	X_c	α	Bradley.	LaCaille.	Magn.	Time. 1700+	W.
	° ′ ″		″		° ′	″	″	*m.*	*a.*	
ε Boötis	+28 8 28.6	......	......	......	218 31	30.0	28.6	3	49.5	2
μ Herculis	27 52 64.7	......	......	60.7	264 10	58.7	62.7	3.4	51.1	4
α Andromedæ	27 42 32.0	......	......	......	358 53	32.3	32.0	2	50.2	2
μ Cygni	27 37 25.5	......	......	......	323 15	26.6	25.5	3.4	50.6	2
α Coron. bor.	27 34 18.2	......	......	......	231 2	15.2	18.2	2.3	49.5	2
β Cygni	27 27 8.9	......	......	......	290 10	4.2	8.9	3	49.7	2
μ Leonis	27 10 8.9	......	14.8	......	144 37	14.6	11.9	3	53.0	4
β Pegasi	26 43 52.5	......	......	......	342 55	55.4	52.5	2	50.6	2
41 Arietis	26 12 43.9	......	......	......	38 50	45.5	43.9	4	50.1	2
ε Geminorum	25 20 58.7	......	......	......	97 8	64.3	58.7	3	49.2	2
δ Herculis	25 9 5.2	......	......	*1.3	256 27	5.2	3.9	3	49.7	3
ε Leonis	24 54 34.8	......	37.3	......	142 54	40.6	36.0	3	53.2	4
ζ Leonis	+24 39 4.1	......	4.1	......	150 41	4.1	4.1	3	53.0	4

Star.	X_p	C'_p	X_c	X'_c	α	Bradley.	LaCaille.	Magn.	Time. 1700+	W.
	° ′ ″	″	″	″	° ′	″	″	*m.*	*a.*	
η Tauri	+23 18 36.6	......	38.6	......	53 10	37.1	37.6	3	53.2	4
μ Geminorum	22 36 50.6	......	53.4	......	91 57	53.6	52.0	3.4	54.2	4
η Geminorum	22 33 7.4	......	9.4	......	89 57	8.0	8.4	3.4	54.3	4
δ Geminorum	22 24 58.2	......	62.8	......	106 17	61.9	60.5	3	54.4	4
γ Cancri	22 20 52.2	......	53.4	......	127 12	46.9	52.8	4	54.6	4
α Arietis	22 16 1.4	5.6	*0.7	......	28 17	1.5	2.3	3	53.7	4
β Herculis	22 3 6.6	5.7	*12.9	......	244 52	7.2	7.6	3	53.7	4
δ Leonis	21 53 13.4	......	22.0	......	165 11	19.5	17.7	2.3	54.5	4
γ Leonis	21 5 43.2	......	44.5	......	151 32	41.8	43.8	3	54.5	4
ζ Tauri	20 57 43.4	......	48.1	......	80 41	49.2	45.8	3	54.5	4
ζ Geminorum	20 54 38.8	......	40.5	......	102 19	41.7	39.6	3	54.5	4
α Boötis	20 29 27.8	35.5	38.0	......	211 14	31.4	33.4	1	53.7	5
γ Herculis	19 45 27.7	26.1	......	......	241 43	28.4	27.2	3	54.5	3
η Boötis	19 39 42.0	......	40.9	......	205 42	37.7	41.5	3	54.4	4
β Arietis	19 34 26.8	28.7	29.8	......	25 13	27.2	28.4	3.4	53.2	5
δ Cancri	19 3 14.4	......	19.5	......	127 37	13.4	17.0	4	54.6	4
e Pegasi	18 44	50.1	......	......	317 37	52.2	50.1	4	50.6	1
ε Tauri	18 36 7.2	9.2	9.9	......	63 31	5.6	8.7	3	53.5	5
γ Arietis	18 3 32.8	......	30.0	......	24 58	23.6	31.4	4	54.4	4
η Leonis	17 58 21.1	......	13.7	......	148 25	12.2	17.4	3	54.7	4
α Sagittarii	17 27	24.8	......	......	292 14	24.2	24.8	4	50.7	1
δ^1 Tauri	16 55 61.6	......	60.4	......	62 8	57.7	61.0	3.4	54.1	4
δ^2 Tauri	16 50 31.6	......	......	......	62 26	27.9	31.6	4	56.1	2
θ Leonis	16 47 30.2	......	28.6	30.2	165 16	26.5	29.6	3	53.7	5
γ Geminorum	16 35 14.1	......	11.8	15.1	95 49	12.8	13.4	2.3	54.0	5
γ Serpentis	16 29 34.2	39.9	39.7	......	236 14	35.7	37.5	3	53.7	5
β Serpentis	16 13 17.7	......	11.1	......	233 40	14.8	14.8	3	54.0	5
α Tauri	15 58 61.1	62.3	55.4	60.0	65 24	55.1	59.8	1	53.2	6
β Leonis	15 58 5.7	......	3.0	6.2	174 4	4.5	4.7	2	53.8	5
γ Delphini	15 14	18.0	......	......	308 46	18.5	10.0	3.4	50.7	1
α Delphini	15 2	47.0	......	......	307 0	44.7	47.0	3	50.7	1
γ Tauri	+15 0 5.5	4.2	2.1	......	61 24	3.2	3.9	3	53.5	5

* Only one observation.

Mean declination for 1750.0 (*corrected*)—Continued.

Star.	X_p	C'_p	X_c	X'_c	α	Bradley.	LaCaille.	Magn.	Time. 1700+	W.
	° ′ ″		″		° ′	″	″	*m.*	*a.*	
ζ Boötis	+14 48 54.3	....	48.5	50.5	217 18	51.1	51.2	3	53.8	5
α Aquilæ	14 44 52.8	52.3	......	......	282 4	56.7	52.6	3.4	54.8	3
ε Herculis	14 41 42.9	40.3	39.3	43.8	255 49	43.1	41.4	2.3	53.1	1
δ Delphini	14 11	32.1	......	......	307 57	36.6	32.1	3.4	50.7	1
α Pegasi	13 51 57.2	50.6	*56.0	......	343 5	53.8	55.3	2	53.8	4
ζ Delphini	13 49	46.9	......	......	305 54	41.4	46.9	4	50.7	1
γ Pegasi	13 47 33.3	31.6	30.6	30.4	0 6	33.8	31.6	2	52.8	6
β Delphini	13 44	27.4	......	......	306 27	30.3	27.4	3	50.6	1
ζ Aquilæ	13 30 41.9	38.4	......	......	283 29	39.7	40.7	3.4	54.8	3
α Leonis	13 10 48.8	......	41.2	39.7	148 45	39.5	43.9	1	54.0	5
α Cancri	12 48 32.4	......	30.9	.....	131 12	?	31.6	5	54.6	3
α Ophiuchi	12 45 42.4	43.4	43.3	......	260 50	43.2	43.0	2.3	53.8	5
ε Virginis	12 18 31.1	......	30.1	......	192 26	31.6	30.6	3	53.9	4
δ Serpentis	11 23 28.1	25.5	28.1	......	230 43	27.7	27.6	3	53.8	5
ο Leonis	11 0 61.3	......	53.8	......	141 57	56.7	57.6	4	54.6	4
ε Delphini	10 28	15.2	......	......	305 19	14.0	15.2	3.4	50.6	1
ρ Leonis	10 35 10.6	......	4.0	4.7	154 54	4.4	6.8	4	54.0	5
γ Aquilæ	10 1 19.8	20.6	16.6	......	293 35	23.2	18.7	3	53.5	5
β Cancri	9 56	......	3.4	......	120 44	8.7	3.4	3.4	52.2	2
ζ Pegasi	9 31 69.4	58.1	......	......	337 15	60.6	65.6	3	54.1	3
β Can. Min	8 46 19.2	......	16.2	......	108 24	14.2	17.7	3	54.6	4
ε Pegasi	8 44 29.7	25.9	25.3	......	322 58	28.2	27.2	3	53.2	5
α Aquilæ	8 13 41.5	39.6	40.4	42.4	294 39	41.8	41.0	1	53.8	6
α Orionis	7 20 12.0	......	8.0	......	85 25	10.3	10.0	1	54.3	4
α Serpentis	7 13 53.2	45.0	47.9	......	233 0	48.9	49.4	2.3	53.6	5
γ Orionis	6 5 54.3	......	52.5	59.1	77 56	58.9	54.5	2	53.7	5
Procyon	5 50 35.7	......	39.2	42.1	111 33	36.2	38.5	1.2	54.0	5
β Aquilæ	5 48 2.7	10.1	5.4	......	295 45	3.3	5.3	3	53.4	5
ε Serpentis	5 14 61.6	51.7	53.4	......	234 35	56.2	56.3	3.4	53.7	5
δ Virginis	4 45 42.6	......	45.4	37.8	190 45	42.7	42.8	3	53.9	5
β Ophiuchi	4 41 40.5	33.3	38.9	......	262 47	37.7	38.4	3	53.8	5
α Equulei	4 13	43.4	......	......	315 50	....	43.4	4	50.6	1
θ Serpentis	3 54	1.3	......	......	280 57	53.55.7	61.3	4	50.7	1
β Virginis	3 10 20.4	......	20.2	......	174 25	20.7	20.3	3	54.5	4
α Ceti	3 5 31.4	38.8	31.4	28.5	42 19	35.0	32.2	2	53.3	6
γ Ophiuchi	2 49 24.7	25.7	26.6	22.6	263 51	26.0	25.1	3	53.4	6
δ Aquilæ	2 38 18.4	19.5	9.4	......	288 13	13.9	15.0	3	53.5	5
γ Ceti	2 9 59.3	67.5	62.0	......	37 36	63.6	62.0	3	53.4	5
α Piscium	1 32 44.6	......	......	......	27 17	42.8	44.6	3	56.4	2
η Virginis	0 43 29.8	......	31.1	29.1	181 47	?	30.2	3.4	54.1	5
ζ Virginis	0 41 24.1	......	24.5	24.1	200 30	26.8	24.2	3	53.7	5
η Antinoi	+0 23 4.3	......	3.0	......	294 56	6.6	3.7	3	54.3	4
γ Virginis	−0 4 24.3	......	24.6	......	187 15	26.0	24.5	3	54.3	4
δ Orionis	−0 30 22.7	......	22.0	27.8	79 49	22.4	23.4	2	53.7	5
δ Ceti	−0 45 51.3	......	49.8	56.7	36 41	49.7	51.8	3	53.9	5
ε Orionis	−1 22 59.4	......	66.5	60.0	80 53	62.7	62.4	2	53.7	5

Star.	X_p.	X_c.	X'_c.	C_c.	α	Bradley.	LaCaille.	Magn.	Time. 1700+	W.
	° ′ ″				° ′	″	″	*m.*	*a.*	
α Aquarii	−1 31 23.9	28.6	......	......	328 14	23.7	26.3	3	54.3	4
θ Antinoi	1 32 34.8	39.0	......	......	299 36	35.4	36.9	3.4	54.3	4
ι Antinoi	1 49 9.3	13.9	......	......	290 57	11.5	11.6	3.4	54.3	4
ζ Orionis	2 5 48.9	53.0	47.0	......	82 3	50.6	50.2	2	53.7	5
γ Aquarii	2 38 15.5	16.0	......	......	332 11	15.3	15.8	3	54.3	4
μ Serpentis	2 38	42.9	......	......	234 9	44.3	42.9	4	52.6	2
η Orionis	2 39 4.8	0.3	......	......	77 59	38 56.4	62.5	3	54.5	4
η Serpentis	2 56	32.2	......	......	272 6	31.8	32.2	3.4	51.7	2
δ Ophiuchi	3 1 51.2	48.9	47.5	......	240 19	49.8	49.5	3	54.0	5
ζ Serpentis	3 38	57.7	......	......	266 49	59.9	57.7	4	52.8	2
ε Ophiuchi	4 3 47.7	38.4	37.7	......	241 17	42.0	42.0	3	54.0	5
ο Ceti	4 7 40.8	31.5	30.3	......	31 41	34.0	35.0	var ...	53.7	5
θ Virginis	4 11 51.5	48.3	49.3	......	194 15	50.6	49.8	3.4	53.9	5
λ Antinoi	−5 14	8.2	......	......	283 15	6.5	8.2	3.4	51.7	2

*Only one observation.

Mean declination for 1750.0 (*corrected*)—Continued.

Star.	X_p	X_c	X'_c	C_c	α	Bradley.	La Caille.	Magn.	Time. 1700+	W.
	° ′ ″				° ″	″	″	m.	a.	
β Eridani	−5 25 56.3	51.7	......	......	73 54	53.1	54.0	3	54.2	4
ι Orionis	6 5	46.3	......	......	80 48	43.8	46.3	3.4	52.1	2
β Aquarii	6 39 25.5	24.0	......	......	319 36	24.8	24.7	3	53.9	4
φ Aquarii	7 23 33.3	33.8	......	......	345 20	32.5	33.6	4.5	54.2	4
ο Eridani	7 30	28.2	......	......	59 55	30.4	28.2	4	52.0	2
α Hydræ	7 35 21.1	15.5	......	......	138 50	19.2	18.3	2	54.6	4
β Libræ	8 26 31.7	32.4	......	......	225 54	32.6	32.1	2.3	54.6	4
Rigel	8 30 40.7	39.5	......	......	75 38	40.8	40.1	1	54.2	4
λ Aquarii	8 54 4.3	12.9	......	......	339 53	9.6	8.6	4	54.3	4
26 Monocerotis	8 59	11.3	......	......	112 20	14.7	11.3	4	52.2	2
θ Ceti	9 28 50.1	51.8	......	......	17 53	53.8	51.0	3.4	54.5	4
κ Virginis	9 5	45.0	......	......	209 54	39.5	45.0	4	52.4	2
ζ Eridani	9 45 51.8	53.9	......	......	45 56	(?) 30.4	52.9	3	54.5	4
κ Orionis	9 46	42.9	......	......	83 59	45.7	42.9	2.3	52.1	2
α Virginis	−9 50 49.8	52.6	.....	50.3	198 1	52.3	50.9	1.2	53.5	6

Star.	C_c	X_c	α	Bradley.	La Caille.	Magn.	Time. 1700+	W.
	° ′ ″		° ′	″	″			
ζ Ophiuchi	−10 2 11.8	......	245 51	15.8	12.8	2.3	51.6	2
ε Eridani	10 19	13.7	50 18	(?) 11.0	13.7	3	52.0	2
δ Eridani	10 37	33.6	52 49	33.3	33.6	3	52.0	2
η Ceti	11 30	50.4	14 0	50.6	50.4	3.4	51.9	2
λ Virginis	12 12 20.0	.....	211 24	23.4	20.0	4	51.5	2
ε Ceti	14 56 48.8	......	36 52	50.5	48.8	3	51.7	2
α Capricorni	13 17 58.9	......	300 56	56.0	58.9	3	51.8	2
γ Libræ	13 56 7.1	......	230 24	9.1	7.1	4	51.6	2
γ Eridani	14 14 18.0	......	56 36	16.1	18.0	3	52.0	2
53 Eridani	14 48 40.9	......	66 41	42.5	40.9	3.4	52.1	2
α Libræ	14 59 10.7	6.7	219 16	11.5	8.7	2.3	52.0	4
δ Corvi	15 7 14.7	......	184 15	13.8	14.7	3.4	51.6	2
γ Can. Mj	15 16	56.1	103 7	60.1	56.1	4	52.3	2
η Ophiuchi	15 23 25.2	.....	254 1	25.2	25.2	2.3	51.5	2
β Capricorni	15 32 62.4	59.5	301 44	33 2.2	1.0	3	51.8	4
γ Corvi	16 8 8.9	......	180 45	8.4	8.9	3	51.7	2
Sirius	16 23 36.3	35.6	98 32	38.9	35.9	1	52.0	4
α Crateris	16 58 25.2	.....	161 54	23.7	25.2	4	51.7	2
δ Aquarii	17 8 34.9	......	340 20	38.1	34.9	3	51.8	2
δ Capricorni	17 14 53.7	......	323 18	55.0	53.7	3	51.8	2
γ Capricorni	17 46 38.9	......	321 33	37.5	38.9	3	51.8	2
β Can. Mj	17 51 8.7	......	92 55	5.2	8.7	2.3	52.0	2
α Leporis	18 1 16.3	......	80 26	15.7	16.3	3	52.1	2
γ Scorpii	18 47 17.4	......	239 15	17.0	17.4	4	51.8	2
β Scorpii	19 5 54.8	53.5	237 44	53.9	54.1	2	52.2	4
β Ceti	19 21 47.7	......	7 45	45.8	47.7	2	51.7	2
54 Eridani	20 10 15.5	......	67 23	11.0	15.5	3	52.1	2
δ Leporis	20 55 13.1	......	85 9	12.1	13.1	3.4	52.1	2
β Leporis	20 58 41.8	41.4	79 23	39.8	41.6	3.4	52.1	4
μ Sagittarii	21 5 54.8	......	269 42	49.2	54.8	4	51.5	2
ε Corvi	21 13	44.6	179 20	41.4	44.6	3.4	52.5	2
π Sagittarii	21 23 45.5	50.2	283 43	43.9	47.9	3	51.7	4
γ Hydræ	21 50 41.3	......	196 21	42.7	41.3	3	51.7	2
δ Scorpii	21 53 15.4	......	236 24	15.0	15.4	3	51.5	2
β Corvi	22 0 37.4	......	185 20	38.7	37.4	3	51.7	2
ο Sagittarii	22 4 59.8	......	282 25	53.6	59.8	4	51.7	2
γ Leporis	22 32 56.6	......	83 31	55.6	56.6	3.4	52.2	2
α Corvi	23 20 3.7	......	178 54	0.3	3.7	4	52.2	2
ρ Argûs	23 36 5.6	......	119 13	1.1	5.6	3.4	52.3	2
ξ Argûs	24 15 2.5	......	114 42	14 59.3	62.5	3.4	52.2	2
γ Scorpii	24 16 51.8	......	222 23	52.1	51.8	3.4	51.6	2
θ Ophiuchi	−24 43 19.3	......	256 40	20.3	19.3	3	51.5	2

Mean declination for 1750.0 (*corrected*)—Continued.

Star.	C_e.	X_e	a	Bradley.	La Caille.	Magn.	Time. 1700+	W.
	° ″ ′		° ″	″	″			
σ Scorpii	−24 58 1.6	......	241 31	7.7	1.6	3.4	51.5	2
ι Eridani	25 22 9.5	......	55 46	4.3	9.5	4.5	52.0	2
π Scorpii	25 22 16.5	......	235 57	14.0	16.5	3.4	51.6	2
λ Sagittarii	25 31 57.0	......	273 8	52.6	57.0	3	51.6	2
α Scorpii	25 51 7.4	12.2	243 32	6.0	9.8	1	52.0	4
δ Can. Mj	26 0 55.2	......	104 33	50.6	55.2	2	52.2	2
σ Sagittarii	26 34 50.7	......	270 56	44.0	50.7	2.3	51.6	2
φ Sagittarii	27 13 12.5	......	277 31	8.9	12.3	3.4	51.6	2
b Can. Mj	27 35 45.0	......	102 56	36.5	45.0	4	52.2	2
τ Scorpii	27 40 14.3	......	245 6	17.1	14.3	3.4	51.6	2
α Hydr. med	27 53	45.4	169 59	38.7	45.4	3.4	52.5	2
τ Sagittarii	28 0 34.1	......	282 50	30.5	34.1	4	51.6	2
ρ Scorpii	28 27 35.4	......	235 23	37.5	35.4	4	51.5	2
ε Can. Mj	28 38 59.9	......	102 12	56.0	59.9	3	52.2	2
η Can. Mj	28 49 59.3	......	108 33	75.1	59.3	2	52.2	2
γ¹ Sagittarii	29 33 45.8	......	267 16	......	45.8	4	51.6	2
δ Sagittarii	29 54 18.6	......	271 15	18.0	18.6	3	51.6	2
ζ Can. Mj	29 58 12.1	......	92 41	8.3	12.1	2.3	52.2	2
α Fornacis	29 59 13.7	......	45 22	8.5	13.7	3.4	52.0	2
ζ Sagittarii	30 12 36.2	......	281 40	30.8	36.2	3	51.6	2
γ² Sagittarii	30 23 54.2	......	267 26	48.7	54.2	3.4	51.6	2
ξ Hydræ	30 28 36.1	......	170 11	37.5	36.1	3.4	51.7	2
α Pisc. aust	30 56 24.8	......	340 57	24.7	24.8	1	51.8	2
υ Eridani	31 5 26.5	......	66 21	25.0	26.5	3.4	52.0	2
κ *Centauri*	31 44	34.9	204 22	28.5	34.9	4.5	52.5	2
g *Centauri*	33 11	29.3	203 46	19.2	29.3	4	52.5	2
δ Columbæ	33 19	37.5	93 15	......	37.5	4	52.1	2
ε Scorpii	33 48 40.4	42.8	248 30	38.2	41.6	3	52.1	4
α *Columbæ*	34 13	24.2	82 39	......	24.2	2	52.5	2
ξ *Eridani*	34 25	26.3	62 7	......	26.3	3.4	52.0	2
ε *Sagittarii*	34 28	19.8	271 54	......	19.8	3	52.2	2
θ Centauri	35 7 38.0	......	208 1	......	38.0	3	51.6	2
ι *Centauri*	35 23 12.2	8.4	196 39	......	10.3	3	51.9	4
β *Columbæ*	35 52	42.9	85 33	......	42.9	3	52.5	2
π Argûs	36 39 48.6	......	107 5	......	......	3	52.2	2
β Telscopii	36 48 26.7	......	270 11	......	......	4	51.6	2
λ Scorpii	36 53 33.1	......	259 10	......	......	2.3	51.6	2
υ Scorpii	37 4 0.5	......	258 27	......	......	3.4	51.6	
μ Scorpii	37 35 23.6	......	248 45	......	......	3	51.6	
f Eridani	38 23 59.4	......	54 51	......	......	4	52.0	
γ Gruis	38 31 32.6	......	324 41	......	......	3	51.8	
κ Scorpii	38 52 20.3	......	261 18	......	......	2.3	51.6	
ζ Argûs	39 18 44.9	......	118 42	......	......	2	51.3	
δ Lupi	39 43 14.8	......	226 16	......	......	3.4	51.5	
α Argûs	39 56 40.4	......	115 54	......	......	4	52.2	
ι Scorpii	39 59 55.4	......	262 32	......	......	3	51.5	
γ Lupi	40 18 10.5	......	229 39	......	......	3	51.5	
ν Centauri	40 25 53.0	......	203 39	......	......	3.4	51.5	
η Centauri	41 2 35.3	......	214 56	......	......	2.3	51.5	
α Sagittarii	41 3 27.3	......	286 38	......	......	3.4	51.7	
κ Centauri	41 4 51.3	......	220 45	......	......	3	51.5	
μ Centauri	41 13 4.0	......	203 40	......	......	3.4	51.5	
θ Eridani	41 19 10.3	......	42 12	......	......	3	51.9	
ζ Scorpii	41 54 6.8	......	249 16	......	......	3	51.6	
β Lupi	42 6 20.2	......	220 34	......	......	3	51.5	
λ Argûs	42 26 10.3	......	134 42	......	......	2.3	52.3	
θ Scorpii	42 48 29.9	......	259 51	......	......	2.3	51.6	
σ Argûs	−42 48 31.6	......	110 20	......	......	3	52.2	

Mean declination for 1750.0 (*corrected*)—Continued

Star.	C_c	X_c	α	Mg.	Time. 1700+
	° ′ ″	″	° ′		″
η Scorpii	−42 52 45.7	......	253 35	3.4	51.6
ν Argûs	42 59 31.8	......	97 32	3	52.2
α Phœnicis	43 39 58.7	......	3 28	2.3	51.8
ε Lupi	43 46 2.0	......	226 27	3.4	51.6
γ Phœnicis	44 36 28.3	......	19 22	3.4	51.7
ι Lupi	44 53 34.8	......	210 53	4	51.5
β¹ Sagittarii	44 53 49.5	......	286 9	3.4	51.7
β² Sagittarii	45 14 20.0	......	286 16	4	51.7
δ Cœli	45 30	11.9	65 48	4.5	52.0
ζ Centauri	46 2 45.5	......	205 1	3	51.5
π Lupi	46 3 5.2	......	222 4	4	51.5
α Telescopii	46 4 23.0	......	272 6	3.4	51.7
α Lupi	46 17 47.5	......	216 22	3	51.5
γ Argûs	46 36 42.0	......	120 28	2	52.2
γ Centauri	47 35 0.0	......	186 58	2.3	51.5
β Phœnicis	48 3 49.2	......	13 43	3	51.8
μ Argûs	48 6 25.3	......	159 1	3	52.3
α Indi	48 8 22.5	......	304 58	3	51.7
α Gruis	48 9 30.3	......	328 5	2	51.8
β Gruis	48 10 59.6	......	336 54	3	51.8
δ Centauri	49 19 47.0	......	178 53	2.3	51.9
α Aræ	49 38 39.5	......	258 8	3	51.6
λ Phœnicis	50 11	22.6	4 49	5	52.1
τ Argûs	50 19 44.2	......	100 56	3.4	52.2
δ Phœnicis	50 22 49.5	......	20 12	4	51.7
ρ Centauri	50 58	35.7	179 41	4	52.4
o Argûs	52 2 38.3	......	128 17	4	52.2
ε Centauri	52 11 2.6	......	201 4	2.3	51.5
Canopus	52 34 11.1	11.1	94 36	1	52.2
ε Aræ	52 44 33.8	......	249 56	4	51.5
χ Eridani	52 51	46.5	26 33	4	52.3
φ Argûs	53 23	15.0	147 2	3.4	52.3
δ Argûs	−53 48 9.7	......	129 27	2.3	52.3

Star.	C_c	X_c	α	Mg.	Time. 1700+
	° ′ ″	″	° ′		″
κ Argûs	−53 57 9.0	......	138 36	2.3	52.2
β Aræ	55 15 26.4	......	256 9	3.4	51.6
ζ Aræ	55 33 37.3	37.4	249 31	4	52.1
α Doradûs	55 34 30.7	......	67 9	3	52.1
γ Crucis	55 42	45.8	184 22	2	52.3
γ Aræ	56 6	22.1	256 6	3	52.5
ζ Phœnicis	56 35	19.2	14 30	?	51.9
δ Crucis	57 21	31.1	180 31	3	52.3
ξ Phœnicis	57 52	58.3	7 30	?	52.2
ι Argûs	58 14	9.4	137 36	3	52.4
β Crucis	58 19	9.1	188 20	2	52.4
η Argûs	58 22	40.2	158 51	2	52.3
α Eridani	58 30	53.5	22 6	1	52.2
ε Argûs	58 42	52.8	124 20	2.3	52.2
ε Crucis	59 1	14.0	182 1	4	52.4
β Centauri	59 9	2.8	206 37	1.2	52.5
β Indi	59 22	20.3	308 46	3.4	51.8
γ Tucanæ	59 36	1.4	345 40	4	52.1
α¹ Centauri	59 47	26.7	215 42	4	52.5
α² Centauri	59 47	10.5	215 42	1	....
γ Argûs	60 24	23.0	155 48	3.4	52.3
δ Aræ	60 26	5.1	257 9	3.4	52.5
α Tucanæ	61 29	35.7	330 17	3	52.0
λ Centauri	61 38	21.6	171 6	3.4	52.1
α Equulei pictorii	61 40	41.1	101 24	3.4	52.2
α Crucis	61 42	48.1	183 14	1	52.3
β Tria. a	62 37	35.2	233 21	3	52.5
β Doradûs	62 39	30.2	82 52	3.4	52.1
α Hydri	62 47	36.8	27 43	2.3	52.3
θ Argûs	63 5	25.2	158 32	2.3	52.2
α Reticuli	63 6	14.8	62 49	3.4	52.0
α Circini	63 51	48.6	215 40	3.4	52.5
υ Argûs	−63 55	7.3	145 13	3	52.4

Star.	X_c	X'_c	α	Mg.	Time. 1700+
	° ′ ″	″	° ′		″
β Tucanæ	−64 20	23.5	5 0	4	51.6
η Pavonis	64 33 28.7	......	260 19	4	52.2
α Pisc. vol	65 24 10.9	......	134 37	5	52.3
β Reticuli	65 36	0.2	55 18	4	52.0
ζ Tucanæ	66 20 45.9	47.6	1 43	4	52.0
γ Pavonis	66 28 18.2	......	316 21	3.4	52.2
β Muscæ	66 44 6.5	......	187 49	3.4	52.3
δ Pavonis	66 46	47.5	295 59	3.4	51.7
β Pavonis	67 4 8.0	......	305 31	3	52.0
δ Pisc. vol	67 29 58.4	......	109 13	5	52.3
γ Tria. a	67 43 33.0	......	224 0	3.4	52.5
α Muscæ	67 45 16.5	......	185 39	3.4	52.4
α Tria. a	68 31 25.3	......	245 37	2.3	52.5
β Argûs	68 41 26.3	......	137 35	1	52.3
ν Doradûs	68 47 15.5	......	92 36	5.6	52.1
ω Argûs	68 48 6.4	......	151 57	3.4	52.3
δ Hydri	−69 48 5.9	8.0	34 21	4.5	52.0

Star.	X_c	X'_c	α	Mg.	Time. 1700+
	° ′ ″	″	° ′		″
δ Muscæ	−70 11 37.7	......	191 22	4	52.4
γ Muscæ	70 44 54.4	......	184 29	4	52.3
ζ Pavonis	71 35	17.2	273 26	4.5	51.7
G Argûs	71 35 49.8	......	136 5	4.5	52.3
T Argûs	72 45 47.3	......	154 51	4.5	52.3
ε Pavonis	73 31	22.7	292 48	4	51.7
λ Chamæleontis	73 58 36.2	......	178 46	6	52.4
π Chamæleontis	74 30 50.6	......	171 48	6	52.4
κ Hydri	74 46 45.0	50.7	35 25	6	52.0
γ Hydri	74 59 55.2	......	57 52	3.4	52.0
κ Chamæleontis	75 7 47.1	......	178 4	5.6	52.4
α Chamæleontis	76 7 13.5	......	126 9	5	52.3
λ Hydri	76 17 17.6	......	9 58	5.6	51.9
ε Chamæleontis	76 49	44.4	176 54	5	51.5
β Chamæleontis	77 55 19.3	......	181 4	5	52.4
ν Octantis	−78 28 2.0	......	321 45	2	51.8

V.—*Mean Declination for* 1750.0—Continued.

	Star.	X_c	X'_c	a	T.	Mag.		Star.	X_c	X'_c	a	T.	Mag.
		° ′ ″		° ′					° ′ ″		° ′		
β	Hydri	− 78 39 49.8	50.3	3 3	52.0	3_{10}	ζ	Octantis	− 84 37 24.0	......	142 2	52.3	5.6
δ	Chamæleonis	79 13 22.5	......	160 48	52.3	5.6	τ	Octantis S. P.	88 49 56.7	......	330 7	51.8	?
μ	Hydri	80 11 37.9	45.2	39 27	52.0	6	τ	Octantis	91 10 3.1	.....	150 7	52.4	?
δ	Montis Mensæ	80 46 14.6	......	68 56	52.0	6	ζ	Octantis	95 22 31.9	......	322 2	52.4	......
δ	Octantis	82 29 11.5	11.8	207 30	52.3	5	β	Octantis	97 19 39.6	......	154 39	52.4	......
β	Octantis	82 40 28.5	......	334 39	52.1	5	δ	Octantis	97 30 45.0	51.8	27 30	52.5	......
η	Octantis	83 14 50.6	......	165 4	52.4	6	β	Hydri S. P.	−101 20	4.5	183 3	51.7	......
γ	Octantis	− 83 24 28.0	......	354 9	52.5	5							

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	Star.	Declination.	Mag.	a	T.	W.		Star.	Declination.	Mag.	a	T.	W.
		° ′ ″		° ′					° ′ ″		° ′		
β	Hydri	− 78 39 50.9	3	3 3	51.9	4	ζ	Tucanæ	− 66 20 46.5	4	1 43	52.0	3
δ	Octantis	− 82 29 12.2	5	207 30	52.3	6	δ	Hydri	− 69 48 6.6	4.5	34 21	52.0	3
β	Octantis	− 82 40 24.5	5	334 39	52.3	4	κ	Hydri	− 74 46 46.9	6	35 25	52.0	3
ζ	Octantis	− 84 37 26.0	5.6	142 2	52.3	4	μ	Hydri	− 80 11 40.3	6	39 27	52.0	3
τ	Octantis	− 88 49 56.8	?	330 7	52.2	4							

VI.—*A catalogue of* 150 *fixed stars, south of* 30° *Declination, from Lacaille's observations at the Cape of Good Hope, in his "Astronomiæ Fundamenta," for* 1750.0 *and for* 1830.0, *without regard to proper motions.*

No.		Star.	Mean R. A. 1750.0.	Corr'n to R. A.	Mean Declin. 1750.0.	Corr'n to Decl'n.	Mean R. A. 1830.0.	Johnson-La Caille.	Mean Declin. 1830.0.	Johnson-La Caille.
			h. m. s.	s.	° ′ ″	″	h. m. s.	s.	° ′ ″	″
1	ζ	Tucanæ	0 6 52.26	−0.65	−66 20 46.5	− 3.9	0 10 48.57	+21.21	−65 54 2.7	+98.5
2	β	Hydri	0 12 10.96	−1.06	78 39 50.9	− 2.7	0 15 44.73	+58.20	78 13 8.9	+24.5
3	α	Phœnicis	0 13 51.60	−0.52	43 39 58.7	− 6.3	0 17 50.23	+ 1.60	43 13 17.6	−31.2
4	λ	Phœnicis	0 19 17.32	−0.34	50 11 22.6	− 3.9	0 23 11.15	+ 0.48	49 44 44.5	+ 4.8
5	β[1]	Tucanæ	0 19 58.39	−0.59	64 20 23.5	− 4.8	0 23 43.01	− 0.27	63 53 45.8	+ 0.2
6	η	Phœnicis	0 32 1.60	−0.63	58 49 33 †	− 3.0	0 35 41.38	− 0.26	58 23 6	−40
7	λ	Hydri	0 39 50.53	−0.84	76 17 17.6	− 0.4	0 42 38.90	....	75 50 58.5	....
8	β	Phœnicis	0 54 52.22	−0.63	48 3 49.2	− 7.7	0 58 28.84	+ 0.31	47 37 53.0	+ 1.6
9	γ	Phœnicis	1 17 28.09	−0.62	44 36 28.3	−10.2	1 20 58.11	+ 0.42	44 11 18.3	−12.1
10	δ	Phœnicis	1 20 47.83	−0.61	50 22 49.5	− 9.5	1 24 8.18	+ 1.77	49 57 47.3	+17.9
11	α	Eridani	1 28 22.32	−0.60	58 30 53.5	− 3.0	1 31 21.60	+ 0.93	58 6 10.3	+ 0.4
12	λ	Eridani	1 46 12.95	−0.80	52 51 46.5	− 3.6	1 49 14.89	+ 5.47	52 27 55.6	+27.7
13	α	Hydri	1 50 52.90	−0.67	62 47 36.8	− 2.5	1 53 21.38	+ 3.65	62 24 0.1	+ 3.0
14	δ	Hydri	2 17 23.52	−0.21	69 48 6.6	− 0.6	2 18 45.77	− 0.60	69 26 4.4	− 1.6
15	κ	Hydri	2 21 38.73	−0.54	74 46 46.9	+ 0.3	2 21 58.90	....	74 24 59.5	....
16	μ	Hydri	2 37 47.08	−0.79	80 11 40.3	+ 1.7	2 35 28.44	....	79 50 55.6	....
17	θ	Eridani	2 48 47.03	−0.52	41 19 10.3	− 5.9	2 51 49.26	− 0.25	40 59 28.4	+ 4.5
18	α	Fornacis	3 1 27.39	−0.61	29 59 13.7	− 3.0	3 4 49.07	+ 2.37	29 40 36.8	+54.9
19	f	Eridani	3 39 22.76	−0.35	38 23 59.4	− 5.2	3 42 18.89	+ 0.77	38 8 43.7	+ 4.0
20	β	Reticuli	3 41 10.33	−0.66	65 36 0.2	− 2.2	3 42 2.76	+ 3.17	65 20 48.8	+13.4
21	γ	Hydri	3 52 26.79	−0.68	74 59 55.2	− 0.8	3 49 57.62	+ 1.07	74 45 36.9	+ 6.7
22	ξ	Eridani	4 8 26.97	−0.48	34 25 26.3	− 1.9	4 11 27.66	+ 0.33	34 13 4.9	− 0.6
23	α	Reticuli	4 11 16.33	−0.56	63 6 14.8	− 1.8	4 12 14.78	+ 0.67	62 54 4.6	0.0
24	δ	Cœli	4 23 12.02	−0.38	45 30 11.9	− 2.4	4 25 38.27	− 0.17	45 19 21.8	+ 2.0
25	υ	Eridani	4 25 50.5 *	−0.4	31 5 26.5	− 3.6	4 28 56.8	0.0	30 54 55.5	− 0.3
26	α	Doradûs	4 28 36.74	−0.67	55 34 30.7	−15.4	4 30 18.61	+ 1.39	55 24 13.0	+15.8
27	δ	Montis mensæ	4 35 43 81	−0.46	80 46 14.6	+ 0.3	4 29 43.48	....	80 36 17.9	....
28	α	Columbæ	5 30 36.24	−0.61	34 13 24.2	− 3.0	5 33 29.68	+ 0.15	34 10 8.9	− 1.5
29	β	Doradûs	5 31 29.39	−0.20	62 39 30.2	− 2.2	5 32 9.86	− 0.25	62 36 13.4	+ 6.8
30	β	Columbæ	5 42 9.75	−0.35	35 52 42.9	− 3.6	5 44 58.23	+ 0.12	35 50 47.9	+36.2
31	ν	Doradûs	6 10 21.60	−0.63	68 47 15.5	− 1.8	6 9 51.71	....	68 48 26.3	....
32	ζ	Canis Majoris	6 10 43.3 *	−0.9	29 58 12.1	− 3.2	6 13 47.3	+ 0.1	29 59 37.9	+ 3.2
33	δ	Columbæ	6 12 59.20	−0.57	33 19 37.5	− 2.9	6 15 54.63	− 0.39	33 21 18.6	− 0.9
34		Canopus	6 18 24.29	−0.11	−52 34 11.1	− 6.5	6 20 10.58	+ 0.32	−52 36 26.0	+ 5.3

VI.—*A catalogue of* 150 *fixed stars, &c.*—Continued.

No.		Star.	Mean R. A. 1750.0.	Corr'n to R. A.	Mean Declin. 1750.0.	Corr'n to Decl'n.	Mean R. A. 1830.0.	Johnson-La Caille.	Mean Declin. 1830.0.	Johnson-La Caille.
			h. m. s.	s.	° ′ ″	″	h. m. s.	s.	° ′ ″	″
35	ν	Argûs	6 30 6.81	−0.17	−42 59 31.8	− 6.6	6 32 33.59	+ 0.17	−43 3 10.6	+ 6.9
36	τ	Argûs	6 43 43.68	−0.33	50 19 44.2	8.2	6 45 42.65	+ 0.52	50 24 55.4	+ 1.4
37	α	Equulei pictoris	6 45 37.53	−0.14	61 40 41.1	2.5	6 46 28.37	− 1.72	61 46 1.4	+27.1
38	π	Argûs	7 8 18.96	−0.08	36 39 48.6	5.0	7 11 8.55	− 0.11	36 47 49.4	+ 1.0
39	δ	Piscis volantis	7 16 53.08	−0.23	67 29 58.4	2.2	7 16 54.07	− 0.48	67 38 46.9	+ 2.2
40	σ	Argûs	7 21 18.26	−0.53	42 48 31.6	6.1	7 23 51.05	− 0.59	42 57 57.4	+17.0
41	α	Argûs	7 43 37.70	−0.13	39 36 40.4	5.4	7 46 22.87	− 0.32	40 8 30.3	− 0.4
42	ζ	Argûs	7 54 48 15	−0.16	39 18 44.9	5.7	7 57 37.07	− 0.27	39 31 44.3	+ 1.8
43	γ	Argûs	8 1 49 91	−0.63	46 36 42.0	7.5	8 4 18.13	− 0.41	46 50 23.0	+ 2.1
44	ε	Argûs	8 17 21.41	−0.06	58 42 52.8	2.3	8 19 1.51	− 0.32	58 58 3.0	+10.0
45	α	Chamæleonis	8 24 34.21	−0.34	76 7 13.5	1.4	8 22 45.83	+ 1.19	76 22 55.1	+ 8.9
46	ο	Argûs	8 33 7.35	−0.65	52 2 38.3	10.0	8 35 25.42	+ 0.01	52 19 18.9	+ 4.7
47	δ	Argûs	8 37 48.12	−0.25	53 48 9.7	8.8	8 40 0.94	− 0.34	54 5 15.5	− 3.0
48	α	Piscis volantis	8 58 26.77	−0.35	65 24 10.9	2.1	8 59 45.53	− 0.68	65 43 1.4	− 7.4
49	λ	Argûs	8 58 48.51	−0.66	42 26 10.3	6.2	9 1 44.89	0.00	42 45 6.6	+ 7.6
50	G	Argûs	9 4 19.76	−0.43	71 35 49.8	1.7	9 4 40.67	− 1.50	71 55 6.8	− 1.2
51	β	Argûs	9 10 20.92	−0.76	68 41 26.3	1.6	9 11 20.63	− 2.39	69 1 13.6	+ 9.4
52	ι	Argûs	9 10 23.83	−0.42	58 14 9.4	2.4	9 12 33.02	− 0.59	58 33 59.7	+ 9.1
53	κ	Argûs	9 14 23 25	−0.29	53 57 9.0	8.7	9 16 51.88	− 0.46	54 17 18.5	+ 4.7
54	ζ	Octantis	9 28 9.31	−0.57	84 37 26.0	0.7	9 19 55.94	....	84 58 14.2	....
55	υ	Argûs	9 40 50.83	+0.13	63 55 7.3	2.1	9 42 51.74	− 0.59	64 17 9.4	+ 4.1
56	φ	Argûs	9 48 7.07	−0.43	53 23 15.0	2.5	9 50 54.75	− 0.38	53 45 46.8	+ 7.9
57	ω	Argûs	10 7 46.81	−0.38	68 48 6.4	1.7	10 9 42.58	− 0.93	69 11 46.0	+ 3.1
58	I	Argûs	10 19 22.01	−0 64	72 45 47.3	0.2	10 21 0.51	− 0.03	73 10 2.5	− 0.8
59	ρ	Argûs	10 23 11.70	−0.13	60 24 23.0	2.4	10 26 0.69	− 0.79	60 48 50.9	+ 7.8
60	θ	Argûs	10 34 5 97	−0.46	63 5 25.2	2.4	10 36 55 09	− 0.12	63 30 22.0	+ 3.3
61	η	Argûs	10 35 25.66	−0.35	58 22 40.2	2.5	10 38 29.35	+ 0.02	58 47 41.0	+ 7.7
62	μ	Argûs	10 36 4.43	−0.40	48 6 25.3	8.9	10 39 28.03	+ 0.62	48 31 28.1	+ 3.9
63	δ	Chamæleonis	10 43 11.57	−0.50	79 13 22.5	0.6	10 44 9.85	− 3.47	79 38 39.3	+ 2.5
64	η	Octantis	11 0 15.9	−0.9	83 14 50.6	0.1	11 0 21.2	....	83 40 41.5	....
65	ξ	Hydræ	11 20 45.2*	−0.5	30 28 36.1	3.1	11 24 40.6	− 1.	30 54 59.8	− 3.0
66	λ	Centauri	11 24 23.04	−0.39	61 38 21.6	2.1	11 27 59.35	− 0.10	62 4 49.2	+ 3.1
67	π	Chamæleonis	11 27 9.83	−0.45	74 30 50.6	1.4	11 30 22.28	....	74 57 20.7	....
68	ε	Chamæleonis	11 47 37.42	−0.46	76 49 44.4	1.4	11 51 21.77	− 3.29	77 16 27.7	− 2.4
69	κ	Chamæleonis	11 52 16.00	−0.21	75 7 47.1	1.3	11 56 11.35	....	75 34 31.6	....
70	λ	Chamæleonis	11 55 2.31	−0.24	73 58 36.2	1.4	11 59 3.09	....	74 25 21.0	....
71	δ	Centauri	11 55 31.03	−0.38	49 19 47.0	8.1	11 59 35.35	− 0.16	49 46 31.9	+ 1.3
72	ρ	Centauri	11 58 42.92	−0.25	50 58 35.7	2.6	12 2 49.02	− 0.57	51 25 20.7	+ 4.5
73	δ	Crucis	12 2 2.04	−0.45	57 21 31.1	2.9	12 6 10.71	− 0.43	57 48 15.8	+ 6.3
74	β	Chamæleonis	12 4 16.50	−0.8	77 55 19.3	0.9	12 8 36.47	− 2.80	78 22 3.7	− 1.8
75	ε	Crucis	12 8 2.70	−0.55	59 1 14.0	4.0	12 12 16.30	− 1.73	59 27 55.9	+17.4
76	α	Crucis	12 12 55.17	−0.59	61 42 48.1	2.7	12 17 13.99	− 1.32	62 9 29.6	+ 9.8
77	γ	Crucis	12 17 27.48	−0.53	55 42 45.8	3.1	12 21 46.63	+ 0.84	56 9 24.9	−10.7
78	γ	Muscæ	12 17 54.03	−0.56	70 44 54.4	1.6	12 22 26.92	− 1.09	71 11 33.2	− 2.4
79	α	Muscæ	12 22 34.50	−0.42	67 45 16.5	1.3	12 27 8.75	− 0.07	68 11 52.1	+ 1.6
80	γ	Centauri	12 27 51.32	−0.39	47 35 0.0	7.4	12 32 12.34	− 1.41	48 1 31.2	+ 2.0
81	β	Muscæ	12 31 15.15	−0.56	66 44 6.5	2.3	12 35 57.49	− 0.33	67 10 34.3	+ 1.7
82	β	Crucis	12 33 18.17	−0.66	58 19 9.1	2.8	12 37 50.80	+ 0.40	58 45 34.8	+ 6.9
83	δ	Muscæ	12 45 29.30	−0.53	70 11 37.7	2.0	12 50 37.45	+ 5.74	70 37 47.5	+ 0.3
84	ι	Centauri	13 6 37.91	−0.20	35 23 10.3	5.1	13 11 6.12	− 1.94	35 48 43.4	− 2.1
85	ε	Centauri	13 24 14.11	−0.38	52 11 2.6	8.5	13 29 10.93	− 0.39	52 35 54.1	+ 1.1
86	ν	Centauri	13 34 37.80	−0.12	40 25 53.0	5.0	13 39 21.01	− 0.22	40 59 16.4	+ 5.1
87	μ	Centauri	13 34 40.18	−0.48	41 13 4.0	6.0	13 39 24.47	+ 0.24	41 37 27.3	+ 4.4
88	g	Centauri	13 35 3.09	−0.18	33 11 29.3	3.4	13 39 36.99	+ 0.48	33 35 51.7	− 1.5
89	κ	Centauri	13 37 29.57	−0.23	31 44 34.9	3.4	13 42 3.20	− 0.74	32 8 50.2	+ 2.2
90	ζ	Centauri	13 40 5.13	−0.26	46 2 45.5	7.7	13 44 58.97	− 0.04	46 26 52.5	+ 3.0
91	β	Centauri	13 46 26.92	+0.01	59 9 2.8	2.8	13 51 55.20	− 0.70	59 32 49.1	− 1.8
92	δ	Octantis	13 50 1.0	−0.9	82 29 12.2	2.3	14 0 48.5	− 8.1	82 52 37.9	+ 0.3
93	θ	Centauri	13 52 3.92	−0.38	35 7 38.0	4.8	13 56 45.70	− 3.17	35 31 7.1	−40.0
94	ι	Lupi	14 3 31.42	−0.52	44 53 34.8	22.1	14 8 32.96	+ 0.81	45 16 23.1	+17.5
95	η	Centauri	14 19 44.71	−0.10	41 2 35.3	6.2	14 24 44.69	+ 0.23	41 24 21.0	+ 0.4
96	α	Circini	14 22 39.00	−0.39	−63 51 48.6	− 2.7	14 28 55.03	....	−64 13 19.7	....

VI.—*A catalogue of* 150 *fixed stars, &c.*—Continued.

No.	Star.		Mean R. A. 1750.0.	Corr'n to R. A.	Mean Declin. 1750.0.	Corr'n to Decl'n	Mean R. A. 1830.0.	Johnson-Lacaille.	Mean Declin. 1830.0.	Johnson-Lacaille.
			h. m. s.	s.	° ′ ″	″	h. m. s.	s.	° ′ ″	″
97	α^2	Centauri	14 22 49.90	−0.01	−59 47 10.5	− 3.0	14 28 45.31	−37.53	−60 8 41.5	+68.3
98	α	Lupi	14 25 27.27:	0.0	−46 17 47.5	− 7.8	14 30 40.55	− 0.33	−46 39 9.0	+ 0.5
99	β	Lupi	14 42 16.49	−0.33	−42 6 20.2	− 6.4	14 47 26.03	+ 0.24	−42 26 27.6	− 4.6
100	κ	Centauri	14 43 0.65	−0.17	−41 4 51.3	− 6.0	14 48 8.14	+ 0.20	−41 24 55.3	− 0.7
101	π	Lupi	14 48 14.58	−0.31	−46 3 5.2	− 7.5	14 53 35.78	− 0.66	−46 22 44.2	+ 0.6
102	γ	Trianguli australis	14 56 0.25	−0.41	−67 43 33.0	− 2.9	15 3 11.53	− 1.13	−68 2 29.9	+ 0.8
103	δ	Lupi	15 5 3.77	−0.36	−39 43 14.8	− 5.7	15 10 14.49	+ 0.06	−40 1 31.2	+ 1.4
104	ε	Lupi	15 5 49.39	−0.32	−43 46 2.0	− 6.7	15 11 10.34	+ 0.18	−44 4 14.0	− 0.1
105	γ	Lupi	15 18 34.51	−0.30	−40 18 10.5	− 6.4	15 23 50.12	+ 0.50	−40 35 15 6	+ 0.5
106	β	Trianguli australis	15 33 22.95:	0.0	−62 37 35.2	− 3.2	15 40 16.97	− 2.10	−62 53 13.9	−29.6
107	α	Trianguli australis	16 22 28.25	−0.51	−68 31 25.3	− 2.8	16 30 44.59	+ 0.49	−68 42 1.4	− 2.6
108	ε	Scorpii	16 34 1.06	−0.22	−33 48 41.6	− 2.4	16 39 13.73	− 3.56	−33 58 12.7	−20.7
109	μ	Scorpii	16 34 59.53	−0.24	−37 35 23.6	− 5.7	16 40 22.38	− 0.03	−37 44 47.8	− 0.1
110	ζ	Scorpii	16 37 3.18	−0.11	−41 54 6.8	− 6.0	16 42 39.14	....	−42 3 16.7	....
111	ζ	Aræ	16 38 2.73	−0.16	−55 33 37.4	− 6.4	16 44 35.59	− 0.49	−55 42 37.7	+ 1.4
112	ε	Aræ	16 39 44.90	−0.30	−52 44 33.8	−10.7	16 46 3.57	+ 0.27	−52 53 23.6	+ 7.1
113	η	Scorpii	16 54 18.06	−0.11	−42 52 45.1	− 6.7	16 59 59.45	+ 0.16	−42 59 59.8	−18.4
114	γ	Aræ	17 4 25.53	−0.07	−56 6 22.1	− 3.6	17 11 6.54	− 0.06	−56 12 24.7	+ 4.7
115	β	Aræ	17 4 35.17	−0.05	−55 15 26.4	− 9.7	17 11 11.32	0.0	−55 21 28.2	+ 0.5
116	δ	Aræ	17 8 36.86	−0.16	−60 26 5.1	− 2.8	17 15 47.31	− 0.61	−60 31 37.4	− 5.5
117	α	Aræ	17 12 33.78	+0.09	−49 38 39.5	− 8.4	17 18 43.11	− 0.15	−49 43 48.2	− 0.4
118	ν	Scorpii	17 13 47.87	−0.26	−37 4 0.5	− 5.1	17 19 12.94	+ 0.12	−37 9 3.3	+ 0.7
119	λ	Scorpii	17 16 39.56	−0.39	−36 53 33.1	− 5.1	17 22 4.31	+ 0.22	−36 58 16.2	+ 3.7
120	θ	Scorpii	17 19 23.17	−0.27	−42 48 29.9	− 6.7	17 25 6.65	+ 0.22	−42 52 53.1	+ 6.7
121	η	Pavonis	17 21 16.42	−0.23	−64 33 28.7	− 2.5	17 29 4.67	− 0.37	−64 37 31.6	−11.4
122	κ	Scorpii	17 25 13.08	−0.13	−38 52 20.3	− 5.9	17 30 44.18	+ 0.04	−38 56 3.8	+ 5.8
123	ι	Scorpii	17 30 7.99	+0.17	−39 59 55.4	− 6.4	17 35 42.83	− 0.71	−40 3 4.6	− 0.1
124	γ^1	Sagittarii	17 49 3.60	−0.11	−29 33 45.8	− 3.1	17 54 9.91	− 0.06	−29 34 44.5	+ 3.2
125	γ^2	Sagittarii	17 49 45.5*	0.0	−30 23 54.2	− 3.4	17 54 53.9	− 0.4	−30 24 47.9	−11.7
126	η	Sagittarii	18 0 42.79	−0.28	−36 48 26.7	− 5.0	18 6 8.50	− 0.92	−36 48 2.7	− 9.6
127	δ	Sagittarii	18 4 59.5*	....	−29 54 18.6	− 3.2	18 10 6.6	+ 0.1	−29 53 25.7	− 1.1
128	ε	Sagittarii	18 7 34.84	−0.27	−34 28 19.8	− 3.9	18 12 53.87	− 0.51	−34 27 8.1	−12.2
129	α	Telescopii	18 8 25.65	−0.05	−46 4 23.0	− 6.3	18 14 22.23	− 0.29	−46 3 3.2	− 0.8
130	ζ	Pavonis	18 13 43.04	−0.27	−71 35 17.2	+ 1.6	18 23 8.78	− 0.48	−71 33 8.3	−17.0
131	ζ	Sagittarii	18 46 41.3*	+0.3	−30 12 36.2	− 3.2	18 51 42.8	0.0	−30 6 54.0	+ 3.8
132	β^1	Sagittarii	19 4 36.54	−0.09	−44 53 49.5	− 7.1	19 10 24.10	− 0.10	−44 46 3.6	− 2.8
133	β^2	Sagittarii	19 5 5.89	−0.09	−45 14 20.0	− 6.7	19 10 54.61	....	−45 6 30.8	....
134	α	Sagittarii	19 6 30.80	−0.12	−41 3 27.3	− 5.8	19 12 5.33	+ 0.32	−40 55 29.4	− 6.9
135	ε	Pavonis	19 31 11.40	−0.24	−73 31 22.7	+ 2.0	19 40 45.79	+ 0.99	−73 20 30.0	−10.6
136	δ	Pavonis	19 43 55.61	0.00	−66 46 47.5	+ 1.1	19 51 42.67	+15.69	−66 34 40.0	−93.4
137	α	Pavonis	20 5 41.36	+0.03	−57 30 29†	− 3.	20 12 8.68	+ 0.18	−57 16 13	− 2
138	α	Indi	20 19 51.76	−0.07	−48 8 22.5	− 7.3	20 25 34.17	+ 0.43	−47 52 46.4	+10.4
139	β	Pavonis	20 22 4.51	+0.01	−67 4 8.0	− 2.5	20 29 32.50	− 0.52	−66 48 14.4	− 0.4
140	β	Indi	20 35 3.40	−0.03	−59 22 20.3	− 2.7	20 41 27.79	− 0.30	−59 5 18.0	+ 2.4
141	γ	Pavonis	21 5 24.49	+0.10	−66 28 18.2	− 3.4	21 12 16.01	+ 0.47	−66 8 40.4	+62.0
142	γ	Gruis	21 38 42.41	+0.15	−38 31 32.6	− 4.4	21 43 36.45	+ 0.15	−38 9 33.2	− 3.8
143	α	Gruis	21 52 20.57	+0.01	−48 9 30.3	− 7.9	21 57 28.03	+ 0.73	−47 46 38.5	−10.4
144	α	Tucanæ	22 1 7.10	+0.01	−61 29 35.7	− 3.2	22 6 47.71	− 0.93	−61 6 12.1	+ 1.6
145	β	Octantis	22 18 34.91	−1.02	−82 40 24.5	+ 1.9	22 28 11.93	− 6.11	−82 16 0.0	− 3.1
146	β	Gruis	22 27 36.50	+0.23	−48 10 59.6	− 7.9	22 32 27.73	+ 0.94	−47 46 16.7	+ 2.7
147	α	Piscis australis	22 43 46.8*	0.0	−30 56 24.8	− 3.1	22 48 13.	+ 0.75	−30 31 11.9	− 3.9
148	γ	Tucanæ	23 2 39.00	−0.81	−59 36 1.4	− 3.3	23 7 27.69	− 0.52	−59 10 2.3	+ 5.0
149	γ^1	Octantis	23 36 34.87	....	−83 24 28.0	− 3.0	23 42 1.33	−11.34	−82 57 49.6	+ 1.6
150	ν	Octantis	....	....	−78 28 2.0	....	....	....	....	....
151	τ	Octantis	....	....	−88 49 56.8	....	....	....	....	....

(*) signifies the R. A. not from Lacaille's observations, and (†) signifies the declination not from Lacaille's observations.

N. B.—The corrections of the declination of G Argûs (50) and κ Chamæleonis (69) relate to the values used by Lacaille for reduction of the Zones. In Lacaille's catalogues the declination of these stars are more erroneous by about 40″ and 2′ respectively.

REPORT ON THE PRECEDING REDUCTION OF LA CAILLE'S OBSERVATIONS.

By Prof. C. H. F. PETERS.

From the middle of the last century dates the modern art of observing, which requires us to analyze theoretically the instruments used, considering them as a complex of lines and circles, whose positions by an apt arrangement of the observations themselves are then referred to the fundamental points and planes of the heavens. Bradley and La Caille mark this epoch.

The star places observed by Bradley have thus become the foundation, the *terminus a quo*, for comparison with the modern observations, which they still to-day almost equal in rank as to accuracy. Next to Bradley was La Caille, the most skillful observer of the age. But, while the former disposed of the royal means of the Greenwich Observatory, the latter, less favored by circumstances, had to content himself with a small observatory erected at the Collège Mazarin. Nevertheless, with the immense industry he is said to have possessed, he succeeded in making star determinations comparable in accuracy with Bradley's, though of course much fewer in number. In the mean time he obtained the advantage over Bradley in one point, namely, when the occasion was offered to him to examine the Southern hemisphere. Here, at the Cape of Good Hope, besides the measurement of an arc of the meridian, the determination of the parallax of the Moon (in conjunction with Lalande at Berlin), the first application of a proper method for obtaining the solar parallax (by observations of Mars in conjunction with Wargentin's at Stockholm), the observation in zones of 10,000 stars between the south pole and the tropic of Capricorn, La Caille determined, with particular care, a number of principal stars, which to Bradley, on account of his northern position, were invisible. These determinations stand to the southern portion of the starry heavens in the same relation as Bradley's to the northern, and form the starting point for researches on proper motion of the southern stars. But, to be wholly available for this purpose, a re-reduction with the employment of modern constants was needed. While Bradley's observations have had the good fortune of being discussed and elaborated by the master-hand of Bessel, now precisely sixty years ago (Bessel's Fundamenta were published in 1818), La Caille's have hitherto remained in the same shape to which the author himself reduced them. The catalogue published by Baily, in the fifth volume of the Memoirs of the Royal Astronomical Society, is nothing but a reprint of the catalogue in La Caille's "Fundamenta Astronomiæ."

The long-desired work of a new reduction, accomplished by Dr. Powalky, lies now before us in manuscript, together with the laborious computations appertaining thereto, which allow of an examination of Dr. Powalky's work in detail. From the remarks that precede, defining La Caille's situation, it will be perceived that the principal result (though by no means the only one) of Powalky's work is the new catalogue for the epoch 1750 of the stars, 150 in number, between the south pole and $-30°$ declination that were observed by La Caille repeatedly with two different instruments, a 6-foot sector and a 6-foot sextant. For investigating the errors of these instruments, for finding the pole or zenith points, for asçertaining the clock rate, the influence of refraction, &c., it was not sufficient nor feasible to treat those southern stars separately; it was necessary, on the contrary, to take up together all the stars observed in the same night. Dr. Powalky has extended his computation still further, upon the observations made, by the use of the same instruments at the Collège Mazarin, so that the reduction now comprises all of La Caille's fundamental determinations (excepting only the few made at Klyp Fonteyn, the northern terminus of his arc, and at the Isle de France).

The new reduction of the *northern* stars, which admit of comparison, gives a favorable idea of La Caille's observations; the declinations especially appear not inferior to Bradley's.

Unfortunately La Caille's *solar* observations are imperfect, so that the equinoctial point, when derived therefrom, remains uncertain, and Dr. Powalky consequently has assumed it in congruity with Bradley's observations. This seems, under the circumstances, the best way to proceed, though La Caille's right ascensions thereby cease to be absolute, and may in no wise be used in a research about the precession constant.

The declinations, likewise, in their final form, had to undergo a correction in a manner empirical. For, after the observed zenith distances had been corrected and reduced to mean declinations for the epoch (beginning of 1750), the latter, when compared with those of Bessel's Bradley, showed systematic deviations, which, perhaps, may be attributed to defects of La Caille's instruments that cannot now be ascertained. But whatever be the cause, whether an eccentricity, as Powalky inclines to think, or an irregular shape of the pivots, a flexure of the telescope, a faulty length of the graduated arcs (the errors of division strictly so called were examined by La Caille himself, and we find them noted in the "Fund. Ast."), the first terms of a periodical series seem to represent well the deviations. Dr. Powalky, therefore, assuming the form $x \sin \delta + y \cos \delta$, determined for each instrument and for each series separately, the coefficients x and y by the method of least squares. For the Cape, for this purpose, the comparisons with Bradley were used in combination either with some stars observed both in upper and lower culmination, or with certain zenith stars observed in both positions (face east and west) of the sector. The ultimate instrumental corrections, computed by these formulas, indeed bring La Caille's declinations in close harmony both among themselves and with Bradley's.

Another proof in favor of the new reduction is the value found by Powalky for the latitude of La Caille's station at Cape Town. We owe to the exertions of Sir Thomas Maclear the discovery of the exact spot where La Caille's instrument had been situated, and Maclear not only connected it by a triangulation with the Royal Observatory, but made upon the same spot (or quite near it, so that any influence of the mass of Table Mountain upon the plumb-line was the same), two series of observations with the 12½-foot Bradley zenith sector, sent out from Greenwich for the verification and extension of La Caille's arc of meridian. For the latitude of La Caille's observatory thus follows:

	° ′ ″
By geodetical connection with the Royal Observatory	−33 55 17.36*
By the amplitude from the Royal Observatory measured with Bradley's sector, 35 stars	−33 55 15.70*
By Powalky's new reduction from La Caille's observations	−33 55 15.8
La Caille himself used for the catalogue in the "Fund. Ast."	−33 55 13.3

The agreement between the second and third values is surprising, and, though, in part certainly accidental, speaks well for La Caille's accuracy in observing, as at the same time it gives testimony in favor of the new reduction by the improvement in representing the observations.

In the reductions of the Paris observations Powalky has used the latitude 48° 51′ 25″.6, as communicated to him by the late Admiral Davis. The observatory of the Collège Mazarin is stated (Conn. de Temps * *) to be 17 toises east and 1189.5 toises north of the "Observatoire Impérial." With Bessel's dimensions of the ellipsoid the latter number equals 1′ 15″.06, and the latitude of the then Imperial Observatory is 48° 50′ 11″.3±0″.05 (Ast. Nach., No. 1093). The more correct value for the Collège Mazarin, therefore, seems to be 48° 51′ 26″.4. The difference, however, is of little consequence; it is included, besides, in the ultimate empirical correction to the declinations that has been already referred to.

Through the present reduction, La Caille's observations have received a treatment that they long deserved. The care that has been bestowed upon the work by Dr. Powalky makes it a final one. For it is not probable that it will ever need to be repeated for any reasons similar to those that have led to a re-reduction of Bradley's observations, now nearly finished by Dr. Auwers. For a discussion of that character La Caille's are not fundamentally sufficient.

The catalogue of the 150 southern stars Powalky has given for two epochs—1750 and 1830—the places brought down to the latter epoch with Bessel's constants of precession, without regard to proper motion. The difference from Johnson's Catalogue, therefore, may be taken as the amount of proper motion in 80 years, considering that Bessel's precession is nearly true.† As all the stars in question have now been reobserved at Melbourne (Catalogue for 1870) and at the Cape of Good

* I have here substituted for the latitude of the Royal Observatory the value adopted as the latest and most probable by Mr. Stone ("Results of Ast. Obs. made at the Cape of Good Hope, 1874, page XIX), which is about one-quarter of a second greater than that used by Maclear. Also, I have taken for the amplitude the mean resulting from all the stars observed with Bradley's sector, while Maclear selects 16 of them, viz, those the proper motion of which he could derive from La Caille's (older) positions (see Maclear's work on the Arc of Meridian, Vol. I, p. 36, and Vol. II, p. 438).

† The extraordinary proper motion Powalky finds for α Fornacis (or 12 Eridani, as the star now is usually called) arises from a mistake of 1^m made in writing the R. A. for 1830.

Hope (Catalogue for 1860, and "Observations," 1872–'76), it would have been as well, perhaps, to take the year 1870 for the later epoch, whereby the interval would have been increased to one hundred and twenty years.

The column of differences between La Caille's Catalogue in the "Fund. Ast." and the new reduction shows that the corrections are considerable, not only those of the declinations, but also of the right ascensions. That the sign of the corrections in right ascension for nearly all the stars is the same (negative, or La Caille's right ascensions too large) is a significant fact that has a bearing upon many researches. For example, the result of Mr. Galloway's attempt to determine the motion of the solar system in space from southern stars (Phil. Trans., 1847) will need a thorough modification.

Furthermore, the catalogue of La Caille's principal stars, as now prepared by Powalky, was a work necessary to precede a new reduction of La Caille's zones, if this ever should be undertaken. The zone catalogue of 9,766 stars, edited by or under the auspices of the British Association, is, as Argelander has already remarked, loosely prepared, and does injustice to La Caille's skill as an observer. Since all these stars (or rather all of them lying south of $-35°$) have been determined with great accuracy in the last six years by the Meridian Circle at the Cape of Good Hope under Mr. Stone's direction, these recent determinations, together with Powalky's Catalogue, would furnish the elements to rigorously investigate and to eliminate the errors of the micrometer employed by La Caille in the zones, and hence to produce an improved catalogue of the zone stars for 1750.

The foregoing exposition has made it clear, I hope, that the work of Dr. Powalky is a very valuable contribution to science. The computations involve a great amount of labor. An examination of them, as far as it could be done, has shown that they are made with the author's customary care and circumspection, and justifies the undersigned in recommending a remuneration from the National Academy.

C. H. F. PETERS.

HAMILTON COLLEGE, *Clinton, N. Y., March* 22, 1878.

ERRATA TO APPENDIX NO. 22, COAST AND GEODETIC SURVEY REPORT FOR 1882.

Page 506, line 8, after "affected," insert: "as Mr. Schott has remarked, by the old arc of Peru, the real error of which no doubt greatly exceeds that which the calculation attributes to it."

Page 507, line 10, for "60" read "62."

Page 507, line 27, for "greater" read "less."

Page 515, last line, omit "XI."

Page 516, line 3, at the beginning of the line insert "XI."

APPENDIX No. 22.

REPORT OF A CONFERENCE ON GRAVITY DETERMINATIONS, HELD AT WASHINGTON, D. C., IN MAY, 1882.

In pursuance of a correspondence between Major (now Lieut. Col.) J. Herschel, R. E., and the Superintendent of the United States Coast and Geodetic Survey, relative to the most advantageous mode of prosecuting pendulum observations and the scientific value of the same, the following-named gentlemen met at the Coast Survey Office, May 13, 1882, for an informal conference: The Superintendent of the Coast and Geodetic Survey; Major Herschel, R. E.; Prof. C. S. Peirce, Prof. S. Newcomb (on the part of astronomy), and Messrs. George Davidson and C. A. Schott (on the part of geodesy). Maj. J. W. Powell, Director of the United States Geological Survey (on the part of geology), was unable to attend.

The proceedings of the conference were as follows:

TWO LETTERS.

[Read to the conference to explain the immediate cause of the meeting.]

No. 1.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, May 4, 1882.

Maj. J. HERSCHEL, R. E., *Brevoort House, New York:*

MY DEAR SIR: In pursuance of my letter of yesterday's date, I will now submit to you the proposition that, as Superintendent, &c., I invite at once, or at your earliest convenience, a conference on gravity observations, the participants in which would be, beside yourself and Peirce, Newcomb, on the part of astronomy; King and Powell, on the part of geology; and Davidson and Schott, on the part of geodesy. During such conference the greatest range of discussion would of course be in place, but its outcome, I conceive, must necessarily be formulated in a few propositions, some of which would be mainly intended to recite the scientific objects and usefulness of such work, and commend it to public patronage, others, to define the degree of accuracy to be attained in the observations, in order to entitle them to be ranked as contributions to science. As neither you nor ourselves are charged with any special powers in the premises, it appears to me that no other useful results can be reached by a conference than some such public declarations, the value of which rests upon the standing of the party making them. If this proposition meets your views, I shall be happy to make such arrangements for the earliest day you may find convenient. I regret that it will be necessary to tax you with coming to Washington, as all other parties are here, and being officially engaged it would be out of our power to meet you elsewhere.

It will be well if you will formulate in advance such expressions of opinion as appear to you desirable in the premises, in order that after comparing notes we may be able to submit propositions that will readily meet the assent of the conference.

Yours, very truly,

J. E. HILGARD,
Superintendent.

No. 2.

NEW YORK, *May* 5, 1882.

Prof. J. E. HILGARD:

MY DEAR SIR: I am very glad to learn that you are well inclined towards the idea of a conference, and that now, in fact, it rests with me to indicate when I can be in Washington for the purpose.

As it is not a matter which presses until you have issued invitations, when of course it should not be delayed, and as it will be well to give a few days' notice in any case, I will not consider myself in any way required to hasten my departure from New York, but only to give you as early an indication as I can when I can undertake to be in Washington. At this moment I am not in a position to say precisely, but it will almost certainly be within a week from this date. I shall most likely be able to leave this city about Wednesday next.

With regard to the lines of discussion, it must depend to some extent on the degree of publicity which the proceedings would have. It is not to be denied or concealed that there is coming into existence a certain rivalry between what may be called the German and the English schools. I am anxious that the former shall not wrongly claim American adhesion on the one hand, and on the other that American opinion shall not be wrongfully interpreted as favoring the German system. With reference to this last, for instance, I have just received the following from M. C. Wolf, in the course of a reply to my Washington letter: "Je vous félicite vivement de vos travaux sur le pendule, et surtout d'avoir pris une autre voie que celle dans laquelle les Americains se sont lancés, á la suite des Allemands et des Suisses, J'ai eu ici de vives discussions avec M. Ch. Peirce au sujet de ses expériences avec le pendule reversible de Repsold, instrument qui me parait construit dans de déplorables conditions de stabilité."

Now there is just enough truth in this to make one regret the misapprehension as to the American position. But so long as your survey uses a reversible pendulum, without some very distinct statements as to the principles, such misapprehensions will continue, and the Germans will deny that the Americans stand by the differential method.

I hold it to be a very lamentable thing that men of zeal, eager to advance science, should continue to be misled by the old school of physics into launching upon the difficult and precarious enterprise of absolute determinations of gravity, generally in ignorance of the real difficulties of the research, and *always* indifferent to the utility of such determination. The German school is responsible for this.

This brings before us prominently the question of utility, a question which has always been shirked or disposed of by common-places, devoid of any real force. I know this through having urged (for nearly twenty years), very much in vain, the views which I hold at this day, and which I now see gaining ground so slowly. I sum it up in the broad statement that *we do actually* know the mean figure of the earth *as well as we can know it* so long as the irregularities which deform it remain unknown. It is not the force of gravity which we seek, but the irregularities of the surface.

Now this is one of the points on which, at a conference, I should wish to find unanimity, if it is true, or if not, then a better and more indisputable dogma to take its place.

With this as a foundation, the question becomes one of ways and means to study the irregularities with advantage. Here there is great room for difference of opinion. What can be done depends on the cost, in its most general sense, of doing it. Absolute measurements are indefinitely costly, and may be put aside. Differential measurements, also, are frightfully costly, if conducted as I have been conducting these; but I have had in view to prove incontestably that results of practical value can be obtained with a tenth, perhaps a twentieth, the labor that I devoted to them. All depends on the method.

Another point involved in the question of utility is, as you say, as to the degree of precision demanded. All stations of observation should be recognized from the first as belonging to one of two categories—either they are *points d'appui* or they are not. In the latter case the precision demanded is governed by the degree of irregularity which experience teaches as governing the quantity measured, the distances which separate the points being taken into account. A high degree of precision is plainly needless (for points of the second order) if they are widely scattered, whereas if a number of such points are crowded in a small area, their precision ought to be higher because of the information to be gained by intercomparison. Points of the second order widely scattered have no present value other than as indicating tentatively the degree of disturbance. From this point of view there would seem to be an advantage in placing the stations always *in pairs* so as to indicate the variability as well as the variation.

I must now go further. Scientific observation has two distinct aspects. Viewed in one way, it is seen as a means of livelihood, as an intellectual enjoyment, as an employment, as a pursuit worthy of recognition and encouragement, for every reason except that of its ultimate utility. Viewed in the other way, it is a source of expenditure and a drain upon the available power of the time and country, which can only be justified if it attains useful ends in a reasonably expeditious way. For myself, I doubt if I could conscientiously recommend the expenditure of public money on pendulum observations on the ground of their utility; although I could and would recommend it for pendulum *experiments*, having for their object to increase the facility of observation; for I imagine, as things now stand, the prospect of obtaining results in sufficient number and frequency to enable us to study the irregularities successfully is very remote. You will doubtless recognize in this the ground of my inability to offer my services, backed by hopes of support from the British Government, for the prosecution of differential work on this continent. But I have no business to press such considerations on other people, nor to bring them forward at a conference, except incidentally in discussing the proper distribution of stations and the degree of precision demanded. The same arguments and motives had a successful campaign in dictating my latitude work in India; and there is room for their application in the present case. They point out the urgent need for economy in every detail of installation and observation—in the choice of stations and the buildings to be occupied, in the distribution of time to be taken up by the observations, and by the calculations respectively, so as to get, in short, as many results of a sufficient degree of accuracy, and no more, as possible within the year. All this, and much more, seems to me to be involved in the broad question whether or not pendulum research can be satisfactorily carried on with a view to studying the earth's irregularities.

Another phase of this question should deal with the distinction between a study of the large and of the small irregularities. There is a vast difference between such work as that of Malaspina, of Freycinet, of Sabine, of Foster, of Lütke, and of all the other explorers; and that of Kater in England, and of Basevi in India. The work before you here has or may have the characters of both; for the vastness of your disposable area demands a large plan, while the numerous opportunities for prosecuting minuter internal exploration require more special consideration. The degree of precision to be aimed at must be governed partly by what we know of possible variation and partly by what the instruments are capable of. Here, as in other branches of research, we should bear in mind that there is almost always a point in the scale of precision where it becomes questionable whether it would not be wiser to change the whole system if higher precision is wanted. Below that point there is no difficulty. Above it the price to be paid becomes onerous.

You will readily perceive that I fully recognize, as one of the chief subjects upon which discussion should turn, this of requisite precision. At the same time I doubt if it can be discussed to much advantage by those who are not intimate with the figures actually to hand. I would therefore avoid the *vexata quæstio* of probable errors and keep to principles. It is by the latter alone that plans of operation can be governed reasonably. "Frequency to be preferred to accuracy," for example, is a principle easy to limit or extend as may be desired, and far more widely intelligible to the uninitiated than any specification in figures suited to certain categories of cases. Above all we should aim at being intelligible. Without that there will be no outside interest and no support.

* * * * * * * * *

Yours truly,

J. HERSCHEL.

SIX REASONS FOR THE PROSECUTION OF PENDULUM EXPERIMENTS.

By C. S. Peirce.

1. The first scientific object of a geodetical survey is unquestionably the determination of the earth's figure. Now, it appears probable that pendulum experiments afford the best method of determining the amount of oblateness of the spheroid of the earth; for the calculated probable error in the determination of the quantity in question from the pendulum work already executed does not exceed that of the best determination from triangulation and latitude observations, and the former determination will shortly be considerably improved. Besides, the measurements of astronomical arcs upon the surface of the earth cover only limited districts, and the oblateness deduced from them is necessarily largely affected, so that we cannot really hold it probable that the error of this method is so small as it is calculated by least squares to be. On the other hand, the pendulum determinations are subject to no great errors of a kind which least squares cannot ascertain; they are widely scattered over the surface of the earth; they are very numerous; they are combined to obtain the ellipticity by a simple arithmetical process; and, all things considered, the calculated probable error of the oblateness deduced from them is worthy of unusual confidence. In this connection it is very significant, as pointed out by Colonel Clarke (*Geodesy*, p. vi), that while the value derived from pendulum work has for a long time remained nearly constant, that derived from measurements of arcs has altered as more data have been accumulated, and the change has continually been in the direction of accord with the other method. It is needless to say that the comparison of the expense of the two methods of obtaining this important quantity is immensely in favor of pendulum work.

2. Recent investigations also lead us to attach increased importance to experiments with the pendulum in their connection with metrology. The plan of preserving and transmitting to posterity an exact knowledge of the length of the yard after the metallic bar itself should have undergone such changes as the vicissitudes of time bring to all material objects, was at one time adopted by the British Government. It was afterwards abandoned because pendulum operations had fallen into desuetude, and because doubts had been thrown upon the accuracy of Kater's original measure of the length of the second's pendulum. Yet I do not hesitate to say that this plan should now be revived, for the following reasons:

First, because measurements of the length of the second's pendulum, although formerly subject to grave uncertainties, are now secure against all but very small errors. Indeed, we now know that the determinations by Kater and his contemporaries, after receiving certain necessary corrections, are by no means so inaccurate as they were formerly suspected to be. Secondly, metallic bars have now been proved, by the investigations of Professor Hilgard and others, to undergo unexpected spontaneous alterations of their length, so that some check upon these must be resorted to. To this end the late Henri Ste. Claire Deville and Mascart constructed for the International Geodetical Association a metre ruled upon a sort of bottle of platin-iridium, with the idea that the cubic contents of this bottle should be determined from time to time, so as to ascertain whether its dimensions had undergone any change. I am myself charged with, and have nearly completed, a very exact comparison of the length of a metre bar with that of a wave of light, for the same purpose. Neither of these two methods is infallible, however, for the platin-iridium bottle may change its three dimensions unequally, and the solar system may move into a region of space in which the luminiferous ether may have a slightly different density (or elasticity), so that the wave length of the ray of light used would be different. These two methods should therefore be supplemented by the comparatively simple and easy one of accurately comparing the length of the second's pendulum with the metre or yard bar. Thirdly, I do not think it can be gainsaid by any one who examines the facts that the measurements of the length of the second's pendulum by Borda and by Biot in Paris and by Bessel in Berlin do, as a matter of fact, afford us a better and more secure knowledge of the length of their standard bars than we can attain in any other way. So also I have more confidence in the value of the ratio of the yard to the metre obtained by the comparison of the measurements of the length of the second's pendulum at the Kew observatory by Heaviside in terms of the yard and by myself in terms of the metre than I have in all the elaborate and laborious comparisons of bars which have been directed to the same end. I will even go so far as to say that a physicist in any remote station could ascertain the length of the metre accurately to a one hundred thousandth part more safely and easily by experiments with an invariable reversible pendulum than by the transportation of an ordinary metallic bar.

A new application of the pendulum to metrology is now being put into practice by me. Namely, I am to oscillate simultaneously a yard reversible pendulum and a metre reversible pendulum. I shall thus ascertain with great precision the ratio of their lengths without any of those multiform comparisons which would be necessary if this were done by the usual method. These two pendulums will be swung, the yard one in the office of the Survey, at a temperature above 60° F., which is the standard temperature of the yard, the other nearly at 0° C., which is the standard temperature of the metre; and thus we shall have two bars compared at widely different temperatures, which, according to ordinary processes, is a matter of great difficulty. The knife-edges of the pendulums will be interchanged and the experiments repeated. Finally, the yard pendulum will be compared with a yard bar and the metre pendulum with a metre bar, and last of all the yard pendulum with its yard bar will be sent to England, the metre pendulum with its metre bar to France, for comparison with the primary standards; and thus it is believed the ratio of yard to metre will be ascertained with the highest present attainable exactitude.

3. Geologists affirm that from the values of gravity at different points useful inferences can be drawn in regard to the geological constitution of the underlying strata. For instance, it has been found that when the gravity upon high lands and mountains is corrected for difference of centrifugal force and distance from the earth's centre, it is very little greater than at the sea-level. Consequently it cannot be that there is an amount of extra matter under these elevated stations equal to the amount of rock which projects above the sea-level; and the inference is that the elevations have been mainly produced by vertical and not by horizontal displacements of material. On the other hand, Mendenhall has found that gravity on Fujisan, the well-known volcanic cone of Japan, which is about 12,000 feet high, and which is said to have been upheaved in a single night, about 300 B. C., is as much greater than that in Tokio as if it had been wholly produced by horizontal transfer. This conclusion, if correct, must plainly have a decisive bearing upon certain theories of volcanic action. Again, it has long been known that gravity is in excess upon islands, and I have shown that this excess is fully equal to the attraction of the sea-water. This shows that the interior of the earth is not so liquid and incompressible that the weight of the sea has pressed away to the sides the underlying matter. But in certain seas gravity is even more in excess than can be due to the attraction of the ocean, as if they had been the receptacle of additional matter washed down from the land. It is evident that only the paucity of existing data prevents inferences like these being carried much further. On the two sides of the great fault in the Rocky Mountains gravity must be very different, and if we knew how great this difference was we should learn something more about the geology of this region; and many such examples might be cited.

4. Gravity is extensively employed as a unit in the measurement of forces. Thus, the pressure of the atmosphere is, in the barometer, balanced against the weight of a measured column of mercury; the mechanical equivalent of heat is measured in foot pounds, etc. All such measurements refer to a standard which is different in different localities, and it becomes more and more important to determine the amounts of these differences as the exactitude of measurement is improved.

5. It may be hoped that as our knowledge of the constitution of the earth's crust becomes, by the aid of the pendulum investigations, more perfected, we shall be able to establish methods by which we can securely infer from the vertical attractions of mountains, etc., what their horizontal attractions and the resulting deflections of the plumb-line must be.

6. Although in laying out the plan of a geodetical survey the relative utility of the knowledge of different quantities ought to be taken into account, and such account must be favorable to pendulum work, yet it is also true that nothing appertaining to such a survey ought to be neglected, and that too great stress ought not to be put upon the demands of the practically useful. The knowledge of the force of gravity is not a mere matter of utility alone, it is also one of the fundamental kinds of quantity which it is the business of a geodetical survey to measure. Astronomical latitudes and longitudes are determinations of the direction of gravity; pendulum experi-

ments determine its amount. The force of gravity is related in the same way to the latitude and longitude as the intensity of magnetic force is related to magnetical declination and inclination; and as a magnetical survey would be held to be imperfect in which measurements of intensity were omitted, to the same extent must a geodetical survey be held to be imperfect in which the determinations of gravity had been omitted; and such would be the universal judgment of the scientific world.

NOTES ON DETERMINATIONS OF GRAVITY.

By Assistant C. A. SCHOTT.

The conference was invited by the Superintendent of the Coast and Geodetic Survey for the purpose of eliciting an interchange of views respecting the utility and best means of prosecuting pendulum research in the interest of science in general, and with especial regard to the future work of the Coast and Geodetic Survey.

Major Herschel, R. E., having expressed his willingness to favor the meeting with his presence and give it the benefit of his great experience in pendulum work, the time of meeting must be considered extremely favorable.

The following rough notes are offered with a view of inviting discussion on some points considered of importance and interest.

Respecting the question of the utility to geodesy and geology of pendulum work as bearing on the figure and density of the earth, it is sufficiently answered by the resumption of this work in recent years in the leading government surveys conducted in Europe, Asia, and America; but in carrying on these operations different opinions continue to be held as to the best and most economical means both with regard to form of instrument and method of observation.

It may be added that the results already reached are in themselves sufficient to stimulate the further prosecution of the work, since they render it almost certain that still more valuable deductions may be reached.

The pendulum work executed for some years past under the direction of the late Superintendent of the Coast and Geodetic Survey had for its immediate object the study, theoretical and practical, of the best methods available, and to gather the results at various important pendulum stations in Europe, to bring them into strict comparability, and to form a connected system which may be used for combination with similar operations commenced in the United States.

Mr. C. S. Peirce, Assistant, Coast and Geodetic Survey, having brought this work to a close in Europe,* its future prosecution at home now claims renewed attention, both with respect to the economy and efficiency of the plans which it may be desirable to adopt.

The value of the pendulum results depending largely upon their direct comparability and the geographical extent, it would in the first place appear most desirable, in order to form a second and independent connection of the pendulum work executed on the other side of the Atlantic, to swing the American pendulums at the two stations, Washington and Hoboken, just occupied by Major Herschel with the old pendulums belonging to the Royal Society, and to add thereto at least one more American station in order to secure three stations of satisfactory accord between these instruments.

It is, perhaps, the general opinion that differential measures are at present more desirable than absolute measures, since undoubtedly greater accuracy can be reached in the former and a greater number may be secured with the same expenditure; indeed, the determination of the length of a second's pendulum is, in geodesy, of less importance than a knowledge of ratios of times of oscillation of an invariable pendulum swung at stations on a line selected for investigation.

The determination of the length of a second's pendulum is quite a special operation, to be undertaken only at a base station.

While the mean figure of the earth may be considered as tolerably well known from the fact of the close approach of the value of the compression as deducted from purely geodetic operations and

*Mr. Peirce remarked that that work was not yet quite completed.

from pendulum work, yet this may be taken only as an encouragement for the joint prosecution of both operations.*

On the other hand, our knowledge of the magnitude of the mean figure of the earth is, in the opinion of some, not quite as satisfactory, and in support of this it may be stated that the recent abandonment, in the Coast and Geodetic Survey, of the Besselian spheroid of revolution for that of Clarke, involving in our latitude an increase of the radii vectores between one-third and one-half of a statute mile, was no inconsiderable change; and though we cannot look forward to any future change of such a magnitude, the difference was sufficiently large to make itself felt in our oblique arc lying along the Atlantic coast between Maine and Georgia.

The combination of the Peruvian arc, the only one in America as yet worked in with the meridional arcs measured in the eastern hemisphere, with the two arcs measured by the Coast and Geodetic Survey, viz, the Nantucket arc and the Pamplico-Chesapeake arc, showed a satisfactory accord (that is, within limits that may be explained by local deflections). This seems to prove that the curvature of North America does not sensibly differ from the curvature in the same latitudes of the eastern hemisphere; yet the conclusion is weakened by the fact that the Peruvian arc is extremely short, and, what is worse, is supported by but two astronomical latitudes, and that in a region where local deflection probably exists of an excessive magnitude. It is true the computed corrections to the two latitudes are small, and this might lead to too great a confidence in the assigned value of the magnitude of the earth's axis. A remeasure and extension of this arc to be supplied with a considerable number of astronomical latitudes would seem to be a great desideratum, especially when we consider the important position of the arc, giving it, so to say, undue leverage in comparison with the position of other arcs. It is not at all unlikely that the results of its remeasure and extension may have an important effect on our knowledge of the probable uncertainty in the assigned value for the resulting mean figure of the earth.†

This mean figure might be defined as that of a geometrical solid whose surface most nearly approaches the equipotential surface of the mean sea level, intersecting it so that the aggregate of the volumes above and below it may be equal and a minimum. It would be the object of geodesy to trace out on this geometrical surface the boundaries of these areas, and to determine their elevations above or depression below it; in fact, work out the actual irregularities with reference to this ideal mean figure.

For pendulum research the region of the Mississippi Valley would seem to be very favorable, both in regard to its geological structure, as presenting broad features, and with respect to gradual changes in elevation of surface between New Orleans and our northern boundary, near the forty-ninth parallel, the land rising but little above 1,000 feet. Here a study of the law of change of gravity with the latitude seems inviting.

Supplementary to the above line, the thirty-ninth parallel might be chosen for the study of the law of change of gravity with altitude, starting from the sea level and passing over the inconsiderable elevations of about 2,500 feet on the Appalachian range and the descent to the Mississippi Valley, we have the gradual rise of the great plains up to 8,000 feet, and next the lower Rocky Mountain plateau, with a final return to the sea level. While on the first named line about 6 or 8 stations might suffice, on the second from 12 to 15 ought to be contemplated.

Respecting the kind of pendulum most suitable for differential measures of gravity, there may be little difference in practice between the use of two invariable pendulums, the one to check the

*Major HERSCHEL. I do not regard the agreement of geodetic and gravity figures an argument for the latter. I can never regard the geodetic figure, derived from the comparisons of the curvatures of certain *land* portions only, as a true indication of a figure which is two-thirds sea. There is every reason to regard the land curvatures as too great.

†Major HERSCHEL. I should hardly advocate a remeasurement of the Peruvian arc as a step towards a better determination of the earth's figure. It has the fatal disadvantage of position in a valley between vast mountainous tracts.

Mr. PEIRCE. Major Herschel's objection to the important scheme of remeasuring the Peruvian arc would apply, *à fortiori*, against allowing that arc to enter into the determination of the figure. In my humble judgment an American figure of the earth, wholly from geodetic measurements on these continents, is so greatly wanted that it is the duty of this Survey to undertake it. Although the Peruvian arc is at present bad, I should think that if sufficiently extended and provided with an adequate number of latitude determinations, the objections to it would nearly disappear.

other, and an unchangeable pendulum of a plain rod (of lenticular cross-section) having two fixed knife-edges symmetrically disposed; the means for correcting for difference of temperature and for difference of pressure from respective mean quantities to be determined at a base station. Observations to be made in 4 positions (upper knife-edge, lower knife-edge, face front, and face back). The accord of the 4 results will furnish a criterion for the unaltered condition of the pendulum.

A reversible pendulum of outer symmetrical form may also be made to answer the purpose, provided it be swung only with heavy end down (face front and back) and no change whatever is made in the supporting knife-edge or in any other part of the instrument. Two such pendulums would seem desirable in order to detect any change due to accident. With such a pendulum the correction for difference of pressure can be applied with greater certainty than in one of the other forms.

Respecting the stand of the Repsold apparatus, experience has shown it to be unfit for the work, and stiffer support should be provided.

If pendulums could be swung through 24 hours the result could be made independent of variations in the clock rate due to the daily variation of temperature and pressure. The same standard time stars should be observed each night. For shorter durations of swing, say for 6 hours only, this advantage might in a measure be secured either by making four fresh starts and thus continue the work during twenty-four hours, or if that be too laborious, to observe on the first day, say from 6 to 12 a. m. and p. m., and on the following day from 0 to 6 p. m. and a. m., and unite the results into one, or in general, for any station by a *symmetrical distribution* of the swings over the twenty-four hours.

Time furnished telegraphically by an observatory whose clock is protected from changes of temperature and pressure will be preferable to any local determination at a field station.

Should the duration of swing be too limited for this scheme, night work may be recommended, with a set of transit observations just before and another immediately after the close of a swing, the same two sets of stars to be used each night and for several stations as long as practicable.

Three days successful work at any one station may suffice, and about two weeks might be estimated for the time required for occupation during the best season. The observatory to be prepared by an advance party.

The method of coincidences furnishes all needful accuracy, but if, in the absence of a clock or otherwise, a chronometer be used (as more portable and less liable to injury), coincidences of the chronometer beat with the transit of the pendulum over a vertical line might be tried.

The question whether or not it is advisable to swing in a vacuum chamber (say at a density just below any that might naturally be expected at a place which it is proposed to visit) would seem to depend largely upon the time a pendulum can be made to swing advantageously. If its sectional dimensions are such as to displace much air and require it to do much work against friction, the duration of swing may be so short as to demand the use of an exhausted receiver. What the experience is with the new reversible pendulums of the pattern of the one sent last summer to one of the polar research stations of the Signal Corps the writer is not informed.

The above notes are respectfully submitted.

CHAS. A. SCHOTT.

MAY 13, 1882.

COMMUNICATIONS.

GENERAL REMARKS UPON GRAVITY DETERMINATIONS.

By Major (now Lieut. Col.) JOHN HERSCHEL, R. E.

The following propositions are *from my point of view*, but seem likely to be assented to in the main by other members of the conference.

1. *Figure of the earth.*—By this we imply the actual (or conceivable) continuous water surface as exemplified by the mean sea level; which surface may be everywhere nearly, though nowhere fully, represented by some assumed simple geometrical figure, such as an elliptic spheroid, to be known *ad hoc* as the *mean* figure.

2. *Object of pendulum research.*—If we regard the mean figure as known, then the object of pen-

dulum research is, in the first place, to trace out the degree of separation everywhere subsisting between the actual and the mean figures; or, if it should appear that by a change of the mean figure there would result a less degree of separation, then to ascertain, first, what should be the amount of this alteration, and then to trace out the residual separation. Bearing in mind the large body of past work, which has undoubtedly sufficed to indicate very closely what the mean figure is, it should now be recognized as more particularly the object of pendulum research to enlarge our knowledge of the *irregularities of figure* rather than to aim at improving the *mean* figure; which after all can never be anything more than one *of reference*, by which to describe the actual figure.

3. *Extension of research among the irregularities.*—This is *prima facie* desirable, especially when geodetic surveys are in progress, or are certain to be instituted as civilization advances. But gravimetrical exploration in regions which can never be reached by surveying operations is of scarcely less importance.

4. As regards *distribution of stations* of observation, there seems to be nearly equal advantage in laying them out in a *linear series* at sufficiently close intervals, or superficially scattered over a limited selected area, with a view to tracing out the *sectional* or *solid* forms of the existing *irregularities.*

5. *The absolute force of gravity.*—If this also be admitted as an ultimate object of pendulum research, it must be remembered that it can only be determined for the whole earth when the exact relation of the place of observation to the whole surface is correctly known. It follows that a precise knowledge of the absolute force of gravity for the earth as a whole is not at present attainable. There are, nevertheless, reasons for now determining, with all the precision at present possible, *the length of the second's pendulum* at different places on the earth's surface.

6. *Reasons for prosecuting absolute determinations.*—Regarding the local force of gravity as a constant, the length of a pendulum is a function of its rate of oscillation; or, in other words, its rate is a measure of its length. From this it follows that lengths, otherwise incommensurable, can be compared through their corresponding times of oscillation, because we have means (in the pendulum itself, for instance) of comparing together, with any desired degree of precision, these times. Thus, for example, the metre and the yard can be compared by this means (as I understand) with greater precision than by the complicated system of linear comparisons requisite to measure their difference in terms of each.

7. *Constancy of gravity tested against constancy of length.*—This is another reason for determining with the utmost precision the length of the second's pendulum in terms of this or that standard. For if, in the far distant future, there should appear a concurrence of testimony indicating change, it might be brought home to either of the bars, or even to gravity itself, according to the evidence. The absence of the requisite evidence in the past would be a grave reproach hereafter.

8. *The invariable pendulum.*—The impossibility of ascertaining the exact relation of any station to the whole surface, short of a general knowledge of the latter, calls necessarily for such explorations as are set forth in Article 2. It is generally acknowledged that the differential pendulum—of which the "invariable" may be regarded as the type—is best adapted for such work. The pattern known as Kater's has hitherto been without a rival; but any pattern will answer the purpose in which the principle of invariability—*i. e.*, fixity of knife-edge and absence of all movable parts—is embodied.

9. *The reversible pendulum* is recognized as having many excellent qualities; and is capable of being used *temporarily* as an invariable pendulum. But its proper field is the absolute measurement for which it was designed; for if its knife-edges are interchangeable it is liable at any time to have its invariable character destroyed, either intentionally or accidentally.

10. With regard to the degree of precision to be aimed at, nothing very definite can be laid down, since it depends largely on the circumstances. A gross error in a solitary arctic station, for instance, might be of little consequence, while an error of even a small fraction of a second in the difference between two central points would entail far-reaching consequences. When the object is tentative exploration only, accuracy may well be sacrificed to expedition and frequency. And in general it should be remembered that the local disturbance varies with the change of site. What the rate of this change may be can only be guessed until data are obtained. A group of contiguous determinations of a low order of accuracy would always be more valuable than a single one of the

very highest order. A solitary station can contribute only to the general problem of mean figure and will of necessity be vitiated by the amount of the local disturbance, as to which there is no evidence. If the range of such disturbance *on the whole of that parallel* were known, it would not be unreasonable to take one-fourth part of that as the range of probable error permissible in the determination itself. Every consideration which takes into account the existence of local disturbance points to the preference to be given to frequency of distribution rather than accuracy of result. Moreover, it is difficult, if not impossible, to estimate the probable error in any case whatever. The history of pendulum observation abounds with inexplicable contradictions and anomalies indicative of unknown causes of error; and hardly a single observer has ventured to estimate the probable error of his result. Practically, the question of precision is cut by a variety of circumstantial exigencies; and it would seem best to leave it at the discretion of the observer, or director of the work.

11. *Other modes of research.*—The foregoing indicates so plainly the need of tentative exploration of a low order of accuracy that it is very much to be desired that some simpler means should be found of obtaining at least a rude measure of the local deflection. Various statical modes have been proposed, but none has yet shown a satisfactory test. That a "stathmometer"—a term designed to leave untouched the present use of "gravimeter"—will some day be invented is highly probable. It might be, perhaps, the sooner if the very great need for it were more widely known, and if, at the same time, it were understood that its object would be served even though it should fail to rival the pendulum in accuracy.

J. HERSCHEL.

Mr. PEIRCE. The conception which Major Herschel has presented for the purpose of gravity determinations requires thorough study. Considered from a purely mathematical point of view, it is certain that if we know the distribution of gravity over the whole earth, or even over a large region, we can deduce corrections of the earth's radius vector. Within 20° of the station whose radius vector was to be corrected an accurate knowledge of the residuals of gravity would be necessary, while beyond that point a rougher determination would suffice. But whether this conception of the nature of pendulum work could be usefully adopted at the present time, or until two or three times the existing number of stations have been occupied, is a practical question in regard to which there is something to be said on both sides. The views of Major Herschel, though founded on known propositions of mathematics, are so novel and so far-reaching in their consequences that we cannot commit ourselves to an immediate decision in regard to them. But they offer much food for reflection and study, and I am quite sure that apart from the important service that Major Herschel has done us in connecting the American (and through that the continental European) system of stations directly with the great *réseau* of the English work by means of the Kater invariable pendulums, American geodetical science is under great obligation to him for the suggestions contained in the paper he has presented to the conference.

OPINIONS CONCERNING THE CONDUCT OF GRAVITATION WORK.

By C. S. PEIRCE.

I. There are six reasons for determining gravity, which I have already set forth.

II. In determining the compression of the earth's spheroid from the variation of gravity, it is best, for the present, to reject all experiments not made with Kater's invariable pendulums. But the completion of Major Herschel's history of pendulum determinations is greatly to be desired.

Major Herschel thought the limitation to Kater's invariable pendulum too narrow; and pointed out that it would exclude the work of Freycinet and of Duperrey as well as a great part of that of Foster.

III. The ordinary correction for continental attraction is vastly too great. It should be omitted.

Major Herschel remarked: "Admitting this as a conclusion drawn from the facts, it must not be forgotten that this is nothing but an *à posteriori* dogma. I do not see how it can be lawfully acted upon, unless the assumption that it has a true *à priori* cause is kept continually in view *as* *such.*" Mr. Peirce replies as follows: "In my opinion, the correction for continental attraction is not only refuted by observation but it has no *à priori* support from premises which we have any reason to suppose true. If we could make our pendulum experiments underground at the level surface of which the sea-level is a part, there would be no correction to be made for continental attraction. Since they cannot be made there, the observed gravity had to be reduced to what it would be at that level. The coefficient of this reduction depends entirely on the distances of the successive level surfaces without reference to the situation of the material masses, except so far as this situation affects those distances. To calculate the reduction exactly upon this principle would be impossible; but we approximate to it within the limits of other neglected terms if we use Young's rule* without the term depending on continental attraction. Stokes reaches this same result; but having reached it, he remarks that if this theoretically correct procedure were used the figure of the earth would be less regular than in using the old rule. He offers no proof of this, however; and the facts which have been ascertained since his memoir was written prove that the contrary is true. Young's rule supposes that if all the rock rising above the sea-level were annihilated, the present level surface would remain a level surface, which is certainly not true. When Major Herschel admits, as he seems to do, that a certain conclusion is proved by the facts but at the same time maintains it cannot be 'lawfully' acted upon, he seems to be using the language of a game with conventional rules. I would propose to act upon any proposition that seems to be true." Mr. Schott agreed with Mr. Peirce.

NOTE BY MAJOR (NOW LIEUTENANT-COLONEL) HERSCHEL.—I should like the issue between Mr. Peirce and myself, on the general question of the reduction on account of continental or mountain attraction, to be somewhat differently stated than it appears here. In the first place, what I have said about an "*à posteriori* dogma" had reference, if I remember rightly, not so much to the rejection of the continental reduction *in toto* as to its modification by an arbitrary constant, about which Mr. Peirce is now silent. However, my words are general enough, no doubt, to cover this rejection in any form, but all I maintain is that the assumption on which it rests shall be plainly presented and never disregarded. Mr. Peirce contends that the reduction for continental attraction has no claim to any such apologetic treatment, urging that, as it has no rational foundation, it should go; the displacement of matter, which appears as land elevation, being in all probability a merely vertical displacement, while for the continental attraction to have any jurisdiction, it would be necessary to show the existence of at least a very considerable *lateral* displacement as the cause, or part cause, of elevation. Now it is just here that I would step in and urge the claim of the latter, of which there is ample proof in the enormous thickness and extent of stratified deposits, all of which must be due to erosion and removal horizontally. Something also might be said for glacial transfer, and for lava streams.—J. H.

JULY 4, 1883.

IV. The residuals of the different stations are materially diminished by subtracting the entire downward attraction of the ocean, liberally estimated.

Mr. Peirce admitted that this would involve a falsification of the earth's figure, so as to give a sort of mean figure.

Major HERSCHEL. "The addition of the sea attraction has a legitimate *raison d'être*, as it is reasonable to affirm that the *sea* matter is *added* matter."

Mr. PEIRCE. It seems to me if the attraction of the sea is to be allowed for because it is added or horizontally displaced matter, then the attraction of the continents should not be allowed for, because it is not added, that is, is only vertically displaced matter."

V. The occupation of additional arctic stations, if done well, would probably improve the value of the compression. New equatorial stations are also desirable, but new stations in middle latitudes can hardly affect the value of the compression.

Major HERSCHEL. "The actual distribution is shown in a diagram given in my Appendix to Vol. V of the India Survey. This diagram shows how very restricted is the area actually occupied by differential stations. The southern hemisphere is very poorly represented."

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* This so-called rule is identical with *Bouguer's* formula for the same.

VI. In middle latitudes, the main thing at present is to study the relation of gravity to geographical and geological conditions.

Major Herschel concurred.

VII. Gravity determinations should be made at intervals on lines of geodetic levels, and the levels be corrected accordingly.

Mr. Schott concurred.

VIII. Economical questions should, as far as possible, be solved by the application of mathematics.

IX. The invariable reversible pendulum reunites the advantages of the two instruments possessing the one and the other of these characters, and is to be recommended under the limitation implied in No. II above.

Major HERSCHEL. I am obstinately opposed to any attempted combination of the invariable and reversible principles in one instrument. They are incompatible; and the combination is impossible without so modifying the invariable principle that it is practically abandoned altogether. It is very undesirable that any new element of doubt should be imported into the already much abused term "invariable." It was first used by Godin, as well as by Bouguer, and by la Condamine. They all meant a rigid pendulum with fixed knife-edge. Kater borrowed the word from the French, but as he at the same time introduced a "convertible" pendulum, with two fixed knife-edges, which made a great noise abroad, the two got mixed up, and the German text-books (copying from Muncke*) flagrantly confused the two. Still, the German use is strict in denoting a rigid pendulum with fixed knife-edges. But Mr. Peirce now intends to upset this last stronghold of the "invariable" pendulum by making it variable at the will of the observer. The invariable pendulum proper *can* undergo no change without violating its name. Closely connected with the term "invariable," as designating a particular form of construction, is the term "invariability" as denoting a principle involved in its design. I cannot possibly demur to the construction of any form of pendulum which may be thought desirable; but I do urgently protest against the designation of it in a way to create needless confusion. The principle of the invariable pendulum supposes it to continue unchanged as long as human carelessness will permit, or longer if possible. But by making its knife-edges interchangeable, with a view to giving it a greater range of utiltity, this first characteristic is voluntarily destroyed; and in becoming reversible *in the full sense of the word* it ceases to be invariable. Why, then, adopt a self-contradictory compound name which serves no purpose but to ruin the word as well?

At the same time I must say that Mr. Peirce seems to *read the word* differently.

Mr. PEIRCE. By an invariable reversible pendulum, I mean one in which the knives remain in place from one station to another. Major Herschel's objections seem to be directed against the use of the word invariable as applied to such an instrument; but it is not so much the word as the thing that I advocate. The Geodetical Association has unanimously recommended the reversible pendulum, and I should certainly think that their opinion ought to be respected, even if I did not share it. On the other hand, there is much to be said in favor of differential instruments. I am not aware that Major Herschel has brought forward any objection to reuniting the differential or invariable and the reversible principles in one instrument except this, that if the knives can be changed they might be changed by carelessness. But it appears to me that the whole weight of this argument, such as it is, is against the invariable pendulum. For there is no fabrication of human hands that cannot be changed by carelessness. Can a Kater invariable pendulum be safely exposed to careless treatment? The difference between the ordinary invariable pendulum and the invariable reversible pendulum in this respect is that if the former suffers injury the work is hopelessly vitiated, while if the latter is injured, it is only necessary to fall back on the reversible principle. The following are the advantages which I think I see in the use of the invariable reversible pendulum:

1st. It satisfies the requirements of those who advocate the reversible pendulum, who constitute the greater weight of living authority.

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* *Gehler's Physikal. Wörterbuch.* Art. *Pendel.* VII, pp. 304-407. Leipzig, 1833. By far the ablest treatise, historical and otherwise, of its day, and perhaps so still.

2d. It ought to satisfy those persons who advocate the invariable pendulum.

3d. It determines gravity in two nearly independent ways, without more experiments than are necessary for a single determination. When these results agree they may be assumed to be correct.

4th. If the instrument be considered as a differential one, the difference in the reduced time of oscillation with heavy end down and with heavy end up must remain unchanged so long as the instrument is invariable and can hardly escape change otherwise. And from this change the necessary correction can be calculated and applied. If on the other hand the instrument be considered as an absolute one, the same difference is the best test of the accuracy of the work.

Mr. SCHOTT. For the strict intercomparability of results at two or more stations, I think it to be almost essential to satisfactory work that an absolutely invariable pendulum be employed. This condition would, however, not exclude the use of a pendulum having interchangeable knife-edges, provided that between any two stations no such interchange took place, while the interchange might be effected after the particular comparative measures were secured.

NOTE BY MAJOR (NOW LIEUTENANT-COLONEL) HERSCHEL.—The view of this subject here presented by Mr. Schott, in this last paragraph, is so sensibly correct that only a strong conviction that it does not meet the whole case, and is directly opposed to the principle of inviolability which I wish to see recognized, would tempt me to add to this discussion. We are agreed, and universal practice shows it to have been widely recognized, that invariability must be maintained during at least the whole course of a series of differential determinations. [In the East Indian series, for instance, it was maintained during eight or nine years, and at more than thirty installations.] No one pretends to set any limit, either to the time or to the number of stations, which is to restrict a series of differential measures. But it is said, "when the series is completed there is no longer any need to guard or preserve the pendulum from change; its work is done." But it is just at this point, I contend, that we ought, on the contrary, to be growing more and more solicitous for the protection of the pendulum. The more stations it has visited, the more intimate is our knowledge of its time of vibration, or vibration-number, or whatever be the function we may adopt by which the results of observation are to be expressed. Even if, at the time, only one of the stations visited was a "known" station, we ought yet to contemplate and anticipate the time when, by the superposition of later series, the fundamental vibration-number (*i. e.*, its equatorial vibration No.) shall rest on more than one, perhaps on many known stations. Even if such considerations as these fail to convince, some weight will surely be conceded to the argument that, as one continuous series is better than two or more, covering the same stations, and as by merely guarding the pendulum stringently during the temporary pause between two sets of operations, otherwise called series, these will in fact constitute one only, it is right to take the proper precautions to bring this about. I confess I am surprised, not that this principle has not been acted upon, in times past, but that it should at this day need more than the most cursory enunciation, and that we are even now debating whether we shall not continue to throw away one-half of the net results of each set of observations with invariable pendulums. We do no less, when we break off a series and, by interchange of knife-edges, interrupt the continuity of a series.

J. H.

JULY 4, 1883.

X. Four classes of errors affect the observed period of oscillation, as follows:

1st. Those which are nearly constant throughout the work at any one station. Such arise, for example, from the flexure of the support, from an error in the adopted coefficient of expansion at a tropical or arctic station, and from other causes.

2d. Those which remain nearly constant for a considerable time, say an hour or a day, but which vary from day to day. Such arise, for example, from the knife resting differently on the supports on different days, from erroneous determinations of temperature, or from similar causes.

3d. Those which are continually varying throughout the observations.

4th. Those which arise from errors in the comparison of the pendulum with the time-piece.

The first class of errors demand the most solicitous scrutiny. The other three classes may be distinguished by the study of the residuals of the observations. The third class is the most important of the last three.

XI. Further insight into the nature of the errors is obtained by comparing the residuals with large and with small arcs, and by comparing the residuals of the reversible pendulum in its two positions.

Small arcs and heavy pendulums are to be recommended.

Major HERSCHEL. In recommending "small arcs," Mr. Peirce leaves us to guess what magnitude he contemplates. In setting out upon my recent experience, I intended to swing in arcs as small as I could anyway *see* them, certainly below 30″. But I found that both Sir G. Airy and Professor Stokes were strongly opposed to such a course, and I abandoned the intention in favor of arcs falling from say 70′ to 7′. The objections urged were all theoretical. I should still advocate the practical testing of the doubt in any series of observations of an experimental character.

Mr. PEIRCE. I find the errors of observation are not increased by continuing the oscillation down to arcs of 1′.

XII. The method of coincidences as perfected by Major Herschel is to be recommended, especially in connection with a clock whose pendulum swings from knives.

XIII. The experiments should be continued for 24 hours, beginning and ending with star observations, when this is convenient. But this should not be absolutely required.

XIV. The swinging in *vacuo* is to be recommended.

Major Herschel dissented.

XV. The flexure of the support may be advantageously avoided by swinging two pendulums simultaneously on the same support with opposite phases. When this is not done the flexures should be measured, and in doing this the measures must be made at the middle of the knife-support or else the position of the instantaneous axis of motion must be determined.

XVI. The separation of the atmospheric effect into two parts is requisite for an exact temperature correction.

XVII. The influence of atmospheric moisture ought to be studied.

XVIII. The use of rollers in place of knives is to be condemned.

XIX. The probable accidental error of a determination of gravity must not exceed 5 millionths ($\frac{1}{200000}$), and the total which may reasonably be feared must not exceed 10 millionths ($\frac{1}{100000}$).

Professor Newcomb and others agreed to this, but Major Herschel and Mr. Schott objected to any numerical criterion of this sort.

XX. A good gravimeter is an important desideratum.

CONCLUSIONS PROPOSED BY PROFESSOR NEWCOMB, AMENDED AND ADOPTED BY THE CONFERENCE.

1. The main object of pendulum research is the determination of the figure of the earth. From a sufficient number of observations suitably distributed over the surface of the earth the actual figure may be determined.

2. A complete geodetic survey should include determinations of the intensity of gravity. These determinations should be made at as many critical points of local deflection and physical structure within the area of the survey as possible; and these should be combined with others distributed over the whole globe.

3. A minute gravimetric survey of some limited region is at present of such interest as to justify its execution.

4. Extended linear gravimetric exploration is desirable, to be ultimately followed by similar work distributed over large areas.

5. Each series of such determinations should be made with the same apparatus, so that the differential results should not be affected by constant errors peculiar to the apparatus.

6. While it is inadvisable at present to strictly fix a numerical limit of the permissible probable error of pendulum work, yet such determinations ought commonly to be accurate to the $\frac{1}{200000}$ part.

7. Since different pendulums may be used in different regions, all should be compared at some central station.

8. Determinations of absolute gravity will probably prove useful in comparing the yard and the metre, and they should at any rate be made in order to test the constancy of gravity against the constancy of length of a metallic bar.

9. In the present state of our experience, unchanged pendulums are decidedly to be preferred for ordinary explorations.

APPENDIX No. 11.

RESULTS OF THE TRANSCONTINENTAL LINE OF GEODETIC SPIRIT-LEVELING NEAR THE PARALLEL OF 39°. FIRST PART FROM SANDY HOOK, N. J., TO SAINT LOUIS, MO., EXECUTED BY ASSISTANT ANDREW BRAID.

(WITH A MAP).

By CHARLES A. SCHOTT, Assistant.

When the Survey undertook the geodetic connection of the Atlantic and Pacific coasts by a chain of triangles it became evident that a line of spirit-leveling would be needed in order that the various base lines might be accurately referred to the sea level, their common plane of reference. If these elevations were merely known through barometric observations, or ordinary spirit-leveling, the referred length would not possess that degree of accuracy which must be secured in a geodetic operation of refinement and of great extent; it was consequently decided to carry a line of spirit-leveling of precision from ocean to ocean, following, as near as practicable, the triangulation along the thirty-ninth parallel, and resting for its datum level on each side on tidal observations continued for a series of years.

Such a line of levels passing centrally over the country, and thus readily accessible from places lying to the north and south of it, while available for the use of the geographer, the meteorologist, the engineer, the geologist, and others, will have other important scientific bearings upon our knowledge of the physics of the globe; it bears upon the questions of the hydrodynamic equilibrium of the ocean level at different points under the action of disturbing forces, such, for instance, as the following: Is there any difference in height, and, if so, of what amount (from *a priori* considerations it must be small*) between the mean level of the Gulf of Mexico and that of the Atlantic? Or, what difference in the results of precise spirit-leveling have we to expect from levels between two given points by two different routes not on the same level surface? To answer the first question, a branch line from Saint Louis to the Gulf has been already partly executed in connection with the survey of the Mississippi River, and with reference to the second, the investigation will be of great importance, involving, as it does, two effects, viz, that of the inclination of two adjacent equipotential surfaces as related to the general figure of the earth, and the other involving the local deflections of the vertical and irregularities in the intensity of gravity, thus deforming the surfaces of level and altering their distances. Along our east and west line the first or more general effect will be trifling (as it reaches its maximum value in a meridional direction), but the second will enter to its full extent. When crossing the Alleghanies, we can assume that the effect of local deflections will be small, since complete compensation takes place when passing over slopes equal, but oppositely inclined, and, in general, the differential effect may not be cumulative when crossing a number of parallel ridges unless they should all be of similar cross-section. When ascending the great western plains by a long and gentle slope up to the Rocky Mountain Plateau, and then rapidly descending to the sea-level, we have conditions favorable to the development of effect on the results of spirit-leveling due to local deflections in the direction of the vertical and variations in the intensity of gravity. Thus we perceive the intimate connection between geodetic, astronomical, hypsometric, and pendulum work, all of which will be

* It may be mentioned in this connection that spirit-leveling in Europe apparently brought out the result that the mean level of the Atlantic at Brest, France, is higher by one metre than the mean level of the Mediterranean at Marseilles.

prosecuted in the direction indicated. The effects of local deflections mentioned cannot be precisely evaluated under any circumstances so that the question of the relative level of the Gulf and Atlantic might first be ascertained by a line of spirit-levels across the peninsula of Florida (Fernandina to Cedar Keys) and the result compared with that of the line Sandy Hook, Saint Louis, New Orleans (or Mobile). Precisely in the same relation as this short cut stands to the eastern part of our line of levels, the cut across the Isthmus of Panama stands to the whole line, and in both cases these considerations will enter into the discussion of the probable error in the leveling operation when comparing its magnitude with the apparent actual resulting difference at the terminal sea-level.

DETERMINATION OF THE MEAN TIDAL LEVEL* AT SANDY HOOK, N. J.

The tidal observations made at Sandy Hook, by means of a self-registering tide-gauge, commenced October 21, 1875, and have been continued without interruption to the present time. The following table of annual mean readings (in feet) of low and of high waters was communicated to me by Mr. Avery, in charge of the Tidal Division of the office:

	1876.	1877.	1878.	1879.	1880.	1881.		
								Feet.
Mean reading of low water	6.07	6.27	6.36	6.19	6.15	6.13	Mean	6.195
Mean reading of high water	10.69	10.88	11.09	10.90	10.87	10.97	Mean	10.900
Mean range	4.62	4.61	4.73	4.71	4.72	4.84	Range	4.705
Mean reading of half-tide level	8.380	8.575	8.725	8.545	8.510	8.550	Half-tide	8.548
Differences from the mean	− .168	+ .027	+ .177	− .003	− .038	+ .002		± 0.031

A probable error of $\pm$ 0.031 feet or $\pm$ 9.3^{mm} in the starting-level is rather greater than is desirable, and it refers to a mean reading of the sea-level itself roughly determined, since the annual tabular means contain *fractional parts* of a lunation; hence some effect of the semi-monthly inequality in height must be expected to enter into the result. In the mean time Mr. Ferrel submitted these tides to a discussion by the harmonic analysis (compare his Tidal Researches, Washington, 1874; also his discussion of Tides in Penobscot Bay, Appendix No. 11, Coast and Geodetic Survey Report for 1878). He communicated the following table of "Tide-gauge reading of mean sea-level from *hourly* co-ordinates" (uncorrected for shifting of index of gauge between one year and another, the index of 1881 alone being identical with that of the table of low and high waters):

	From lunar tide.	From solar tide.	Difference.
	Feet.	*Feet.*	*Feet.*
1876	5.3423	5.3427	− .0004
1877	5.4292	5.4288	+ .0004
1878	5.0978	5.0977	+ .0001
1879	5.0461	5.0467	− .0006
1880	5.3334	5.3338	− .0004
1881	8.5703	8.5694	+ .0009

Here the results from lunar tide are the mean of five components and the results from solar tide the mean of four components, hence the small difference in the haif-tide level indicated. Calling

*A slight acquaintance with the laws of the tides indicates that the level of reference for spirit-leveling of precision can be no other than the average or so-called half-tide level of the ocean. This matter was also practically tested in 1842, when twenty-two tidal stations were established round the coast of Ireland and their zeros of staffs connected by spirit-levels; the tidal observations have been discussed by the Astronomer Royal (Phil. Trans. Roy. Soc., 1845), and the results will be found on page 551 of the British Ordnance Survey, London, 1858. The spirit-leveling operations of the great trigonometrical survey of India, commenced in 1858, were started from the mean (average) sea-level of Karachi Harbor (Tables of Height in Sind, the Punjab, etc., Calcutta, 1863). In the leveling connecting the Baltic with the Swiss levels the plane of reference is the mean water at Swinemunde depending on fifty-four years of observations. (Leveling in connection with the measurement of arcs, by Dr. Seibt, Berlin, 1882.)

attention to the fact that these values for the several years needed reduction to the same zero level before they could be used, these index corrections were furnished to Mr. Ferrel by the Tidal Division, who applied them, however, to other components (than the above), viz., to O (lunar declinational) and to L (lunar elliptic) and to N (of the same type as L). His corrected hourly readings gave the following values for the mean sea-level:

	Component O.	Component L.	Component N.	Difference O − L.
	Feet.	*Feet.*	*Feet.*	*Feet.*
1876	8.4133	8.4215	8.4212	− .0082
1877	8.5886	8.5651	8.5665	+ .0235
1878	8.7262	8.7516	8.7516	− .0254
1879	8.5435	8.5515	8.5516	− .0080
1880	8.5178	8.5124	8.5122	+ .0054
1881	8.5692	8.5714	8.5715	− .0022

These differences are larger than those exhibited above, which is accounted for by the fact that the results under O and L are not mean values of several terms.

Uniting the results, first combining L and N, their mean with O, and taking the mean of the four values of 1881, we find the following results for the mean reading of the sea-level:

	Feet.	Δ
1876	8.4173	+ .1437
1877	8.5772	− .0162
1878	8.7389	− .1779
1879	8.5475	+ .0135
1880	8.5150	+ .0460
1881	8.5701	− .0091

Mean, 8.5610 ± 0.0289 feet, adopted for the starting-level. From the low and high waters for these years we had the value 8′.548 ± 0′.031 in good accord with the preceding value derived from the harmonic analysis.

The annual values for the mean level as derived from the low and high water $\frac{1}{2}$(L + H) and as deduced from the harmonic analysis (H. A.) compare as follows:

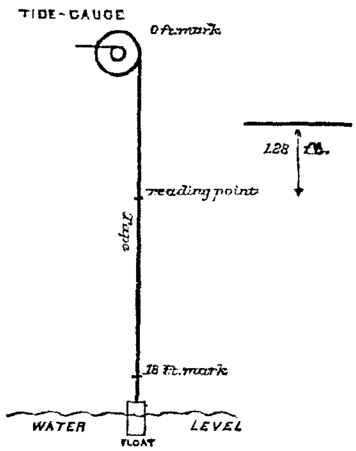
	$\frac{1}{2}$(L + H).	H. A.	Difference.
1876	8.380	8.417	− .037
1877	8.575	8.577	− .002
1878	8.725	8.739	− .014
1879	8.545	8.548	− .003
1880	8.510	8.515	− .005
1881	8.550	8.570	− .020

The level as given by H. A. is found to be higher for every year,* and there is apparently a rise in the mean level during the years 1876–'77–'78, afterwards a fall; but this as well as the apparent increase in the annual range of the tide may be due to accidental circumstances, as disturbing causes of the annual mean height of the sea-level, variations in the mean annual direction and force of the wind, and in the atmospheric pressure, as well as variations in the direction and velocity of ocean currents are prominent factors. There may also be periodic fluctuations in the sea-level

* It is to be remarked that in consequence of the quarter-diurnal tide the high and low waters should both be slightly higher, and consequently also the mean level deduced from them, than the value given by the harmonic analysis; but in fact we find the latter the higher by 0.013 foot or 4.0mm; hence it would seem that the effect is marked by some other irregularity.

(possibly a nineteen-year period) and the relative position of the levels of land and sea* may be subject to a slow secular change.

Changes in the tide-gauge itself, such as changes in the float-line, stretching or contracting of the tape transmitting the motion, and settling of the wharf upon which the tide-house is placed, are of course carefully watched and allowed for when required. For a description of the automatic tide-gauge see Coast Survey Report for 1876, Appendix No. 8. The tide-house is on the freight-wharf of the New Jersey Southern Railroad at Sandy Hook, on its western or inner shore, and about 3km from the point. The tide-house bench mark (designated by T. H. in the table) is a horizontal pencil line with five tacks driven into it on the northwest corner post, and about six feet above the floor of the house; this bench-mark formed the starting-point and level of reference of the line of levels run by Assistant Andrew Braid in 1881. There were other bench-marks established in its neighborhood, and in particular one on the stone tower of the main light-house on the Hook, and another across the narrow channel on the sloping ledge of the southern of the Navesink lights. These marks were connected by Mr. Braid with that in the tide-house, the elevation of which above the mean tidal level, as given by the gauge, is as follows:



	Feet.		Feet.	
Float-line below the 18-foot mark on tape, $8\frac{3}{4}$ inches, or..........	0.729	±	.005	(estimated)
Hence, reading of float-line	18.729			
Reading of mean sea-level or half-tide level (see above)	8.561	±	.029	
Hence, index or reading mark above mean sea-level	10.168			
Tide-house bench-mark above index $15\frac{5}{16}$ inch, or	1.276	±	.005	(estimated)
Hence, bench-mark T. H. above sea-level	11.444	±	.030	
	$=3^{m}.4881 \pm 0^{m}.0091$			

Which value has been adopted for the present. The observations of the tides are continued; hence the probable error of the mean sea-level ($\pm 0^{m}.0088$) may be further reduced hereafter.

The line of spirit-levels between Sandy Hook, N. J., and Saint Louis, Mo., was run by Assistant Andrew Braid with level Coast and Geodetic Survey No. 1, and the metric rods either A and B or E and F. The method of observing was the same throughout. In Coast and Geodetic Survey Report for 1880, Appendix No. 11, Mr. Braid explains his method of observing (pp. 137, 138), describes and figures his instrument (Plate No. 46), and gives a specimen of his record (p. 139), to which the reader may be referred for detail information.

INSTRUMENTAL CONSTANTS.—Magnifying power of telescope 26; focal distance 41cm; aperture 35mm; diaphragm with 3 horizontal and nearly equidistant spider-lines; angular distance middle line to (true) upper line, 1012''.7, and of middle line to (true) lower line 995''.3. One division of micrometer, 442''.8. Value of one division of the level, 5''.32; but this does not enter into the work. The ring inequality was determined on several occasions. The brass scales of the rod were

* Thus at Brest, France, it is stated that the mean level of the ocean from 1834 to 1878 had sunk or the ground had risen about 1mm a year. (Nature, No. 658, June, 1882.) In his annual report of the geological survey of New Jersey for the year 1881, Mr. George H. Cook, State geologist, devotes Chapter III, pp. 20–32, to facts and discussion of the encroachment of the sea upon the low-lying lands. It would appear that the relative change of land and sea along the coast of New Jersey points either to a gradual rise of the sea-level or to a gradual subsidence of the land. The subject of the currents off the coast, and in particular for that part of it lying north of Barnegat, is referred to on page 30. For the mere change of outline of Sandy Hook between the years 1779 and 1853 due to varying currents and supposed unaccompanied by vertical changes, the reader may be referred to Chart No. 8 of Coast Survey Report for 1853. The permanency of our level of reference is of the utmost importance, and if it should be found subject to secular change it may be detected by means of a branch line of levels to some other part of the coast where apparently no indications of change exist. It is the intention of the Superintendent of the Survey to connect the Hagerstown bench-mark with the tide-gauge at Old Point Comfort, Va., and thus secure a check upon its height as well as a second reference to the sea-level.

compared with a standard metre at the office and found of the following length: Rod A = $3^{m}.000105$ at 68°.0 F., and rod B = $3^{m}.000076$ at 68°.3 F., giving the middle metre double weight; the length of the average metre of the rods was $1^{m}.000075$ for A at 68°.4 F. and 0.999996 for B at 68°.3 F. The comparisons of the lengths of the metre marks of rods E and F at 68°.4 F. give the result:

		E	F
Staff metre....	First	$1^{m}.000052$	$1^{m}.000052$
	Second	$1^{m}.000039$	$0^{m}.999959$
	Third	$1^{m}.000121$	$1^{m}.000120$

The coefficient of expansion is assumed equal .00001 For construction of the staves see Assistant Tittmann's paper, Coast and Geodetic Survey Report for 1879, Appendix No. 15. In Appendix No. 11, Report for 1880, Mr. Braid explains the method of leveling followed on the Lower Mississippi River, which is the same as that adopted for the transcontinental line (now extending to Etlah, Mo.), viz: Two parallel lines are run simultaneously and in the same direction, one by staff A, the other by staff B, the rods being placed at different distances from the instrument; alternate parts of the line are run in opposite directions. On level ground, or where the slope is not interfering, the distance from staff to staff (with the instrument as near as may be midway between) is, on the average, 220m, half that distance being stepped off by the rodman when passing from the instrument to the position of the staff. The corresponding staffs of the simultaneous A and B lines are about 20 metres apart.

The following table gives the time of beginning and ending of field work for the several sections of the line and their length:

	Ending.	Beginning.	Distance leveled.
			Kilometres.
Sandy Hook, N. J., to Hagerstown, Md......	1882, July 7	1881, Dec. 12	441
Hagerstown, Md., to Grafton, W. Va.........	1878, May 15	1878, Sept. 7	309
Grafton, W. Va., to Athens, Ohio............	1878, Sept. 7	1878, Dec. 14	228
Athens, Ohio, to Mitchell, Ind...............	1879, July 5	1879, Nov. 8	459
Mitchell, Ind., to Saint Louis, Mo............	1882, July 6	1882, Oct. 21	347
Total development..............................			1 784

The line of levels generally follows a railroad track, with the exception of the space between Hagerstown and Cumberland, Md., where Mr. Braid followed the turnpike for a short distance and afterwards the canal banks. Primary bench-marks are indicated in the record by letters of the alphabet, secondary bench-marks by Roman numerals; the former consist in most cases of a square cavity, three fourths to one inch square and about one-fourth to three-eighths of an inch deep, with legend "U. S. C. & G. S.," and the letter assigned to it; the secondary bench-marks are indicated in the same way, but with a number instead of a letter. The leveling refers to the bottom ledge of the mark. There are also a number of temporary marks, not further described, since most of these will soon become obliterated. A copy of the description of the bench-marks follows the results of each section.* The following names of the more prominent places along the route will, in general, indicate sufficiently the location of the line:

SECTION 1.—Sandy Hook, Perth Amboy, Somerville, Annandale, in New Jersey; Easton, Allentown, Reading, Harrisburg, Chambersburg, in Pennsylvania.

SECTION 2.—Hagerstown, Williamsport, Cumberland, in Maryland.

SECTION 3.—Grafton, Parkersburg, in West Virginia.

SECTION 4.—Athens, Chillicothe, Cincinnati, in Ohio; Lawrenceburg, North Vernon, Mitchell, in Indiana.

SECTION 5.—Vincennes, in Indiana; Olney, Flora, Sandoval, in Illinois; Saint Louis, in Missouri.

The route followed by the leveling party is shown on accompanying map No. 32½.

The office computation was made by Messrs. Christie and Farquhar, of the Computing Division, with temporary aid given by Subassistants Weir and Pratt. The correction for curvature and refraction, for ring inequality, for index error of rods, and variation in length of rods

*In many cases the record contains diagrams to facilitate the finding and identification of the mark, and there are also route diagrams showing the exact location of the line. Application can be made to the office for detail information.

with temperature were duly made when needed; effects arising from change in length of bubble and from collimation error are eliminated in the process of observing. The observer's computation was collated with the office computation, and the final table of results was drawn up by Mr. Christie.

PROBABLE ERROR OF RESULTS FROM GEODETIC SPIRIT-LEVELING.

The probable error of the operation of spirit-leveling of precision developed in a distance of one kilometre has generally been adopted as a convenient measure of stating the precision reached* as well as for comparison of the values of similar work. If, in accordance with the method of least squares we take the probable error of leveling proportional to $\sqrt{s}$, or what comes to the same, the weight of a result to be inversely proportional to the length s, and if—

d = difference in results from two measures of a line of length s, the two measures supposed made preferably in opposite directions and independent of each other,

n = the number of such lines of double leveling,

m' = the mean error of a *single* leveling per kilometre, *i. e.*, per unit of length,

m'' = the same for *double* leveling; then with $p = \frac{1}{s}$

$$m' = \sqrt{\frac{1}{2n}\left[\frac{dd}{s}\right]} \qquad \text{and } m'' = \frac{m'}{\sqrt{2}}$$

r'' = probable error of a double leveling of a line of length $L = [s]$; then†

$$r'' = 0.675\, m'' \sqrt{L}$$

In our case, where the marks are distributed over the whole line with tolerable regularity, the average distance between them being about one km.,‡ and where the weights become equal, the computation of the probable error is much simplified by the use of the formula

$$0.675\sqrt{\frac{\Sigma d^2}{4\Sigma s}}$$

for the probable error in 1km., for a double line; hence, for the resulting difference of height from a double leveling over the whole distance L,

$$r'' = 0.675\sqrt{\frac{\Sigma d^2}{4}}$$

in our case, the two expressions lead to the same numerical value. This probable error must be combined with that of the sea-level or with ± 9.1mm for the tide-house bench mark at Sandy Hook in order to obtain the probable error of the height above the sea. Collecting our results for probable error per kilometre from the double line of levels and for the whole sections, we have:

Section.	Beginning and end of line.	Probable error per kilometre.	Probable error developed from Sandy Hook.	Terminal point.	Bench-mark height above sea.	Probable error.
		mm.	*mm.*		*m.*	*mm.*
I	Sandy Hook, N. J., to Hagerstown, Md	± 1.03	±21.6	Hagerstown, Md............	168.340	±23.4
II	Hagerstown, Md., to Grafton, W. Va.........	1.18	29.9	Grafton, W. Va.............	303.864	31.3
III	Grafton, W. Va., to Athens, Ohio	1.54	37.9	Athens, Ohio	200.155	39.0
IV	Athens, Ohio, to Mitchell, Ind	0.94	43.0	Mitchell, Ind.......	209.681	43.9
V	Mitchell, Ind., to Saint Louis, Mo.	1.05	47.2	Saint Louis, Mo............	126.908	48.1

* With respect to levelings of precision executed of late years in Europe, in the opinion of the Geodetic Association, a probable error in the resulting difference of height as large as $\pm 3^{mm}$ per km. may still be tolerated, but one of $\pm 5^{mm}$ would be considered as surpassing an allowable limit. A value of $\pm 2^{mm}$ may be considered to represent a fair measure and one of $\pm 1^{mm}$ a measure of high precision.

† The formulæ given by Assistant Braid in Coast and Geodetic Survey Report for 1880, page 140, viz:

Mean error of one kilometre for *single* leveling $= \sqrt{\frac{1}{n}\left[\frac{2v^2}{s}\right]}$ and for *double* leveling $\sqrt{\frac{1}{2n}\left[\frac{2v^2}{s}\right]}$

are identical with the corresponding expressions m' and m'' above, since $v = \frac{d}{2}$.

‡ Varying on the average between half a kilometre in the eastern sections to 2 kilometres in the western, according to the natural facilities offered.

The numbers in the last column were found by the combination of the preceding probable errors with that of the sea-level mark (± 9.1mm).* In consequence of the method adopted of running two parallel lines simultaneously, the condition of the entire independence of the two sets of results, as supposed in the above formulæ, is not satisfied, and the computed probable errors are necessarily too small, since the instrumental and atmospheric conditions are nearly the same for the two lines.

Further results will be given as the work progresses.

* About as much would be developed in leveling a line of 60 kilometres.

Transcontinental line of Spirit-levels.

SECTION I.—FROM SANDY HOOK, N. J., TO HAGERSTOWN, MD.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Simultaneous lines. Rod A, first line.	Rod B, second line.	Rods A and B alternately, third line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	*m.*	±*mm.*	*mm.*	*mm.*	$(mm)^2$
T. H. mark	......	0.000	......	......	......	......	+ 3.4881	0.0	......	......	......
T. H. to A	0.415	0.415	− 0.0104	− 0.0156	......	− 0.0130	+ 3.4751	......	+5.2	+ 5.2	27.0
A to B	0.202	0.617	− 0.6155	− 0.6114	− 0.6103	− 0.6124	+ 2.8627	......	−4.1	+ 1.1	16.8
B to 6	0.235	0.852	− 1.3464	− 1.3473	− 1.3445	− 1.3461	+ 1.5166	......	+0.9	+ 2.0	0.8
6 to 9	2.434	3.286	+ 0.0264	+ 0.0279	......	+ 0.0271	+ 1.5437	......	−1.5	+ 0.5	2.2
9 to C	0.707	3.993	+ 4.4090	+ 4.4097	......	+ 4.4094	+ 5.9531	2.3	−0.7	− 0.2	0.5
9 to I	0.575	3.861	+ 3.1769	+ 3.1754	......	+ 3.1761	+ 4.7198	2.4	+1.5	+ 2.0	2.2
6 to 5	3.078	3.930	+ 0.4400	+ 0.4395	+ 0.4430	+ 0.4408	+ 1.9574	......	+0.5	+ 2.5	0.2
5 to II	2.170	6.100	+ 0.3589	+ 0.3622	+ 0.3657	+ 0.3623	+ 2.3197	2.5	−3.3	− 0.8	10.9
II to 4	1.009	7.109	+ 0.9686	+ 0.9656	+ 0.9694	+ 0.9679	+ 3.2876	......	+3.0	+ 2.2	9.0
4 to 3	0.610	7.719	− 0.0462	− 0.0455	......	− 0.0458	+ 3.2418	......	−0.7	+ 1.5	0.5
3 to 1	0.138	7.857	+11.2677	+11.2670	......	+11.2673	+14.5091	......	+0.7	+ 2.2	0.5
1 to 2	0.281	8.138	+22.9924	+22.9891	......	+22.9908	+37.4999	......	+3.3	+ 5.5	10.9
2 to III	0.288	8.426	+24.2156	+24.2136	......	+24.2146	+61.7145	3.0	+2.0	+ 7.5	4.0
III to D	0.038	8.464	+ 1.5598	+ 1.5594	......	+ 1.5596	+63.2741	3.0	+0.4	+ 7.9	0.2
4 to 7	1.960	9.069	− 0.6453	− 0.6432	− 0.6481	− 0.6455	+ 2.6421	......	−2.1	+ 0.1	4.4
7 to 8	1.900	10.969	− 0.4875	− 0.4883	− 0.4906	− 0.4888	+ 2.1533	......	+0.8	+ 0.0	0.6
8 to IV	0.244	11.213	+ 0.6694	+ 0.6689	+ 0.6689	+ 0.6691	+ 2.8224	2.8	+0.5	+ 1.4	0.2
8 to 10	2.553	13.522	− 0.4475	− 0.4448	− 0.4384	− 0.4436	+ 1.7097	......	−2.7	− 1.8	7.3
10 to 11	1.450	14.972	+ 2.6555	+ 2.6596	+ 2.6433	+ 2.6528	+ 4.3625	......	−4.1	− 5.9	16.8
11 to 12	2.268	17.240	+ 0.1413	+ 0.1456	+ 0.1399	+ 0.1423	+ 4.5048	......	−4.3	−10.2	18.5
12 to 13	2.054	19.294	− 1.3603	− 1.3539	− 1.3567	− 1.3570	+ 3.1478	......	−6.4	−16.6	41.0
13 to V	2.420	21.714	− 2.0870	− 2.0897	{ − 2.0907 } { − 2.0854 }	− 2.0882	+ 1.0596	4.3	+2.7	−13.9	7.3
V to 14	1.659	23.373	+ 5.7285	+ 5.7267	+ 5.7308	+ 5.7287	+ 6.7883	......	+1.8	−12.1	3.2
14 to 15	2.282	25.655	+ 2.5068	+ 2.5021	+ 2.4976	+ 2.5022	+ 9.2905	......	+4.7	− 7.4	22.1
15 to 16	1.498	27.153	+ 1.1852	+ 1.1854	+ 1.1776	+ 1.1827	+10.4732	......	−0.2	− 7.6	0.0
16 to E	0.361	27.514	+ 1.2553	+ 1.2570	......	+ 1.2561	+11.7293	4.6	−1.7	− 9.3	2.9
16 to 17	1.996	29.149	+ 7.8762	+ 7.8817	+ 7.8851	+ 7.8810	+18.3542	......	−5.5	−13.1	30.2
17 to 18	2.908	32.057	+ 2.9162	+ 2.9255	+ 2.9251	+ 2.9223	+21.2765	......	−9.3	−22.4	86.5
18 to 19	0.900	32.957	− 8.7006	− 8.6968	− 8.6884	− 8.6953	+12.5812	......	−3.8	−26.2	14.4
19 to 20	1.768	34.725	+20.3191	+20.3169	+20.3240	+20.3200	+32.9012	......	+2.2	−24.0	4.8
20 to 21	1.401	36.126	− 8.8790	− 8.8843	− 8.8828	− 8.8820	+24.0192	......	+5.3	−18.7	28.1
21 to 22	2.924	39.050	+ 0.2465	+ 0.2475	+ 0.2408	+ 0.2449	+24.2641	......	−1.0	−19.7	1.0
22 to 23	1.078	40.128	− 5.1639	− 5.1616	− 5.1676	− 5.1644	+19.0997	......	−2.3	−22.0	5.3
23 to 27	1.369	41.497	+ 2.3214	+ 2.3172	+ 2.3214	+ 2.3200	+21.4197	......	+4.2	−17.8	17.6
27 to 26	2.338	43.835	−11.3133	−11.3042	−11.3203	−11.3126	+10.1071	......	−9.1	−26.9	82.8
26 to 25	0.562	44.397	+ 1.4061	+ 1.4018	+ 1.4018	+ 1.4032	+11.5103	......	+4.3	−22.6	18.5
25 to VI	0.721	45.118	+ 5.2773	+ 5.2771	......	+ 5.2772	+16.7885	7.4	+0.2	−22.4	0.0
25 to 24	0.321	44.718	− 1.2507	− 1.2520	− 1.2563	− 1.2530	+10.2573	......	+1.3	−21.3	1.7
24 to 28	0.419	45.137	+ 1.0689	+ 1.0648	+ 1.0684	+ 1.0674	+11.3247	......	+4.1	−17.2	16.8
28 to 29	1.208	46.345	+ 6.6717	+ 6.6666	+ 6.6674	+ 6.6686	+17.9933	......	+5.1	−12.1	26.0

Transcontinental line of Spirit-levels—Continued.

SECTION I.—FROM SANDY HOOK, N. J., TO HAGERSTOWN, MD.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Simultaneous lines. Rod E, first line.	Simultaneous lines. Rod F, second line.	Rods E and F alternately, third line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Discrepancy. Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	*m.*	±*mm.*	*mm.*	*mm.*	$(mm)^2$
29 to VII	3.556	49.901	−16.2916	−16.2890	−16.2843	−16.2883	+ 1.7050	7.7	−2.6	−14.7	6.8
VII to 30	2.172	52.073	+ 1.7696	+ 1.7713	+ 1.7686	+ 1.7698	+ 3.4748	......	−1.7	−16.4	2.9
30 to VIII	1.458	53.531	+ 0.9598	+ 0.9688	......	+ 0.9643	+ 4.4391	8.3	−9.0	−25.4	81.0
VIII to 34	0.226	53.757	− 1.8068	− 1.8058	......	− 1.8063	+ 2.6328	......	−1.0	−26.4	1.0
34 to F	0.748	54.505	− 0.2687	− 0.2690	......	− 0.2688	+ 2.3640	8.3	+0.3	−26.1	0.1
F to 33	0.642	55.147	+ 2.4160	+ 2.4151	......	+ 2.4155	+ 4.7795	......	+0.9	−25.2	0.8
33 to 32	0.821	55.968	+ 6.3092	+ 6.3076	......	+ 6.3084	+11.0879	......	+1.6	−23.6	2.6
32 to 35	0.754	56.722	+ 5.2727	+ 5.2726	......	+ 5.2727	+16.3606	......	+0.1	−23.5	0.0
35 to 36	1.694	58 416	+ 8.8845	+ 8.8918	......	+ 8.8881	+25.2487	......	−7.3	−30.8	53.3
36 to 37	1.751	60.167	+ 5.0606	+ 5.0682	......	+ 5.0644	+30.3131	......	−7.6	−38.4	57.8
37 to 40	1.486	61.653	− 2.3714	− 2.3762	......	− 2.3738	+27.9393	......	+4.8	−33.6	23.0
40 to 39	1.958	63.611	− 1.3910	− 1.3994	......	− 1.3952	+26.5441	......	+8.4	−25.2	70.6
39 to IX	1.815	65.426	− 1.0509	− 1.0539	......	− 1.0524	+25.4917	9.7	+3.0	−22.2	9.0
IX to 38	0.585	66.011	− 1.1582	− 1.1560	......	− 1.1571	+24.3346	......	−2.2	−24.4	4.8
38 to 44	2.115	68.126	− 2.2584	− 2.2615	......	− 2.2599	+22.0747	......	+3.1	−21.3	9.6
44 to X	2.954	71.080	− 2.6162	− 2.6103	......	− 2.6133	+19.4614	10.0	−5.9	−27.2	34.8
X to 45	0.606	71.686	+ 0.4459	+ 0.4450	......	− 0.4455	+19.9069	......	+0.9	−26.3	0.8
45 to 47	2.907	74.593	− 3.3133	− 3.3177	......	− 3.3155	+16.5914	......	+4.4	−21.9	19.4
47 to XII	1.836	76.429	− 1.6052	− 1.6039	......	− 1.6046	+14.9868	10.0	−1.3	−23.2	1.7
XII to 48	1.834	78.263	+ 2.2515	+ 2.2442	......	+ 2.2479	+17.2347	......	+7.3	−15.9	53.3
48 to 46	1.543	79.806	− 4.9379	− 4.9411	......	− 4.9395	+12.2952	......	+3.2	−12.7	10.2
46 to XI	1.868	81.674	− 2.3987	− 2.3939	......	− 2.3963	+ 9.8989	10.1	−4.8	−17.5	23.0
XI to XIII	0.362	82.036	+ 0.9928	+ 0.9949	......	+ 0.9938	+10.8927	10.1	−2.1	−19.6	4.4
XI to 41	0.554	82.228	+ 0.0006	− 0.0004	......	+ 0.0001	+ 9.8990	......	+1.0	−16.5	1.0
41 to 42	1.469	83.697	+ 0.4699	+ 0.4731	+ 0.4843	+ 0.4758	+10.3748	......	−3.2	−19.7	10.2
42 to 43	1.271	84.968	+ 4.1196	+ 4.1204	+ 4.1230	+ 4.1210	+14.4958	......	−0.8	−20.5	0.6
43 to 49	1.627	86.595	+ 9.0111	+ 9.0135	+ 9.0064	+ 9.0103	+23.5061	......	−2.4	−22.9	5.8
49 to 50	2.450	89.045	− 5.1240	− 5.1195	......	− 5.1218	+18.3843	......	−4.5	−27.4	20.2
50 to XIV	0.368	89.413	+ 6.5511	+ 6.5506	......	+ 6.5509	+24.9352	10.8	+0.5	−26.9	0.2
XIV to G	0.036	89.449	+ 2.8902	+ 2.8899	......	+ 2.8900	+27.8252	10.8	+0.3	−26 6	0.1
50 to 51	2.498	91.543	+ 2.8214	+ 2.8211	......	+ 2.8213	+21.2056	......	+0.3	−27.1	0.1

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod E, first line.	Rod F, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Discrepancy. Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	±*mm.*	*mm.*	*mm.*	$(mm)^2$
51 to 52	3.529	95.072	+ 8.5201	+ 8.5198	+ 8.5200	+ 29.7256	......	+ 0.3	−26.8	0.1
52 to XV	1.785	96.857	− 3.8483	− 3.8546	− 3.8515	+ 25.8741	11.0	+ 6.3	−20.5	39.7
XV to 53	2.681	99.538	+13.0679	+13.0706	+13.0692	+ 38.9433	......	− 2.7	−23.2	7.3
53 to 54	1.370	100.908	+ 4.6154	+ 4.6114	+ 4.6134	+ 43.5567	......	+ 4.0	−19.2	16.0
54 to 55	1.985	102.893	+ 4.6674	+ 4.6631	+ 4.6653	+ 48.2220	......	+ 4.3	−14.9	18.5
55 to 56	2.010	104.903	+ 4.9493	+ 4.9528	+ 4.9511	+ 53.1731	......	− 3.5	−18.4	12.2
56 to 57	1.472	106.375	− 0.5307	− 0.5257	− 0.5282	+ 52.6449	......	− 5.0	−23.4	25.0
57 to 58	1.610	107.985	+13.8987	+13.8971	+13.8979	+ 66.5428	......	+ 1.6	−21.8	2.6
58 to 59	1.613	109.598	+14.6625	+14.6653	+14.6639	+ 81.2067	......	− 2.8	−24.6	7.8
59 to 63	1.594	111.192	+ 7.0621	+ 7.0705	+ 7.0663	+ 88.2730	......	− 8.4	−33.0	70.6
63 to 62	0.518	111.710	+ 4.6206	+ 4.6230	+ 4.6218	+ 92.8948	......	+ 2.4	−35.4	5.8
62 to 61	0.731	112.441	+ 7.2700	+ 7.2689	+ 7.2694	+100.1642	......	+ 1.1	−34.3	1.2
61 to XVI	1.326	113.767	+ 8.0814	+ 8.0827	+ 8.0820	+108.2462	11.8	− 1.3	−35.6	1.7

Transcontinental line of Spirit-levels—Continued.

SECTION I.—FROM SANDY HOOK, N. J., TO HAGERSTOWN, MD.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod E, first line.	Rod F, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	±*mm.*	*mm.*	*mm.*	$(mm)^2$
XVI to 60	1.362	115.129	− 3.3481	− 3.3541	− 3.3511	+104.8951	....	+ 6.0	−29.6	36.0
60 to 70	2.521	117.650	− 4.4895	− 4.4874	− 4.4884	+100.4067	....	− 2.1	−31.7	4.4
70 to 71	1.611	119.261	+10.3865	+10.3890	+10.3878	+110.7945	....	− 2.5	−34.2	6.2
71 to 68	1.608	120.869	+ 9.3449	+ 9.3500	+ 9.3474	+120.1419	....	− 5.1	−39.3	26.0
68 to 67	1.777	122.646	+15.8966	+15.9041	+15.9003	+136.0422	....	− 7.5	−46.8	56.2
67 to 72	2.542	125.188	+18.3370	+18.3326	+18.3348	+154.3770	....	+ 4.4	−42.4	19.4
72 to 73	3.756	128.944	−14.6553	−14.6470	−14.6511	+139.7259	....	− 8.3	−50.7	68.9
73 to 74	1.606	130.550	− 6.9057	− 6.9067	− 6.9062	+132.8197	....	+ 1.0	−49.7	1.0
74 to 75	0.847	131.397	− 2.3667	− 2.3695	− 2.3681	+130.4516	....	+ 2.8	−46.9	7.8
75 to 76	2.378	133.775	−10.4149	−10.4106	−10.4127	+120.0389	....	− 4.3	−51.2	18.5
76 to 77	2.032	135.807	− 7.4857	− 7.4779	− 7.4818	+112.5571	....	− 7.8	−59.0	60.8
77 to 78	2.482	138.289	−10.5440	−10.5416	−10.5428	+102.0143	....	− 2.4	−61.4	5.8
78 to XVII	0.633	138.922	− 2.5670	− 2.5663	− 2.5667	+ 99.4476	13.3	− 0.7	−62.1	0.5
XVII to 82	0.723	139.645	+ 0.7122	+ 0.7073	+ 0.7097	+100.1573	....	+ 4.9	−57.2	24.0
82 to 81	3.019	142.664	− 8.6542	− 8.6549	− 8.6545	+ 91.5028	....	+ 0.7	−56.5	0.5
81 to 80	1.576	144.240	− 0.7811	− 0.7863	− 0.7837	+ 90.7191	....	+ 5.2	−51.3	27.0
80 to XVIII	3.113	147.353	−10.5459	−10.5404	−10.5431	+ 80.1760	13.6	− 5.5	−56.8	30.2
XVIII to 79	1.220	148.573	− 5.9724	− 5.9746	− 5.9735	+ 74.2025	....	+ 2.2	−54.6	4.8
79 to 66	1.206	149.779	− 4.8083	− 4.8071	− 4.8077	+ 69.3948	....	− 1.2	−55.8	1.4
66 to XIX	1.331	151.110	− 4.0314	− 4.0298	− 4.0306	+ 65.3642	13.6	− 1.6	−57.4	2.6
XIX to 65	0.512	151.622	− 2.2295	− 2.2295	− 2.2295	+ 63.1347	....	0.0	−57.4	0.0
65 to 64	0.404	152.026	+29.3191	+29.3195	+29.3193	+ 92.4540	....	− 0.4	−57.8	0.2
64 to XX	0.393	152.419	+16.4387	+16.4387	+16.4387	+108.8927	13.6	0.0	−57.8	0.0
XX to H	0.068	152.487	+ 1.9212	+ 1.9218	+ 1.9215	+110.8142	13.6	− 0.6	−58.4	0.4
XIX to 83	1.764	152.874	+ 1.9025	+ 1.8970	+ 1.8997	+ 67.2639	....	+ 5.5	−51.9	30.2
83 to 84	1.147	154.021	− 1.0912	− 1.0958	− 1.0935	+ 66.1704	....	+ 4.6	−47.3	21.2
84 to 85	2.497	156.518	+ 0.4223	+ 0.4238	+ 0.4230	+ 66.5934	....	− 1.5	−48.8	2.2
85 to 86	1.267	157.785	+ 0.3850	+ 0.3823	+ 0.3837	+ 66.9771	....	+ 2.7	−46.1	7.3
86 to 87	1.468	159.253	+ 0.8361	+ 0.8276	+ 0.8319	+ 67.8090	....	+ 8.5	−37.6	72.2
87 to 88	1.458	160.711	− 0.0900	− 0.0924	− 0.0912	+ 67.7178	....	+ 2.4	−35.2	5.8
88 to 89	2.039	162.750	− 0.0940	− 0.1007	− 0.0974	+ 67.6204	....	+ 6.7	−28.5	44.9
89 to 90	1.786	164.536	− 0.5251	− 0.5309	− 0.5280	+ 67.0924	....	+ 5.8	−22.7	33.6
90 to 91	1.420	165.956	+ 2.7145	+ 2.7192	+ 2.7168	+ 69.8092	....	− 4.7	−27.4	22.1
91 to 94	0.994	166.950	− 0.5240	− 0.5249	− 0.5245	+ 69.2847	....	+ 0.9	−26.5	0.8
94 to 93	1.131	168.081	+ 0.3048	+ 0.2989	+ 0.3019	+ 69.5866	....	+ 5.9	−20.6	34.8
93 to 92	2.482	170.563	+ 2.9417	+ 2.9388	+ 2.9402	+ 72.5268	....	+ 2.9	−17.7	8.4
92 to 95	2.513	173.076	+ 2.1905	+ 2.1868	+ 2.1886	+ 74.7154	....	+ 3.7	−14.0	13.7
95 to 96	1.877	174.953	+ 0.9534	+ 0.9516	+ 0.9525	+ 75.6679	....	+ 1.8	−12.2	3.2
96 to 97	2.252	177.205	+ 1.5440	+ 1.5508	+ 1.5474	+ 77.2153	....	− 6.8	−19.0	46.2
97 to I	1.808	179.013	+20.6964	+20.6961	+20.6963	+ 97.9116	15.0	+ 0.3	−18.7	0.1
97 to XXI	2.142	179.347	+12.9821	+12.9805	+12.9813	+ 90.1966	15.0	+ 1.6	−17.4	2.6
XXI to 102	0.342	179.689	+ 2.5619	+ 2.5631	+ 2.5625	+ 92.7591	....	− 1.2	−18.6	1.4
102 to 101	0.607	180.296	+ 5.2495	+ 5.2505	+ 5.2500	+ 98.0091	....	− 1.0	−19.6	1.0
101 to 100	2.088	182.384	+15.9779	+15.9821	+15.9800	+113.9891	....	− 4.2	−23.8	17.6
100 to 99	2.171	184.555	+ 5.6936	+ 5.6993	+ 5.6965	+119.6856	....	− 5.7	−29.5	32.5
99 to 98	1.314	185.869	+10.4085	+10.4028	+10.4057	+130.0913	....	+ 5.7	−23.8	32.5
98 to 103	3.562	189.431	− 4.5249	− 4.5257	− 4.5253	+125.5660	....	+ 0.8	−23.0	0.6
103 to 104	2.119	191.550	−10.8775	−10.8770	−10.8773	+114.6887	....	− 0.5	−23.5	0.2
104 to XXII	1.092	192.642	+ 2.2782	+ 2.2807	+ 2.2794	+116.9681	15.4	− 2.5	−26.0	6.2
XXII to 105	1.787	194.429	+ 8.0814	+ 8.0732	+ 8.0773	+125.0454	....	+ 8.2	−17.8	67.2
105 to 106	1.642	196.071	+ 9.0241	+ 9.0265	+ 9.0253	+134.0707	....	− 2.4	−20.2	5.8
106 to 107	1.266	197.337	− 4.0234	− 4.0215	− 4.0224	+130.0483	....	− 1.9	−22.1	3.6
107 to XXIII	2.042	199.379	− 0.7061	− 0.7073	− 0.7067	+129.3416	15.7	+ 1.2	−20.9	1.4
XXIII to 112	1.909	201.288	+ 6.8478	+ 6.8469	+ 6.8474	+136.1890	....	+ 0.9	−20.0	0.8
112 to 113	2.738	204.026	+ 5.4299	+ 5.4343	+ 5.4321	+141.6211	....	− 4.4	−24.4	19.4

Transcontinental line of Spirit-levels—Continued.

SECTION I.—FROM SANDY HOOK, N. J., TO HAGERSTOWN, MD.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod E, first line.	Rod F, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	±*mm.*	*mm.*	*mm.*	$(mm)^2$
113 to 114	0.934	204.960	+ 4.6841	+ 4.6841	+ 4.6841	+146.3052	....	0.0	−24.4	0.0
114 to 124	3.851	208.811	− 9.7298	− 9.7229	− 9.7264	+136.5788	....	− 6.9	−31.3	47.6
124 to 123	1.591	210.402	+ 5.2042	+ 5.2053	+ 5.2047	+141.7835	....	− 1.1	−32.4	1.2
123 to 122	1.269	211.671	− 0.7888	− 0.7918	− 0.7903	+140.9932	....	+ 3.0	−29.4	9.0
122 to 121	2.635	214.306	− 4.2477	− 4.2485	− 4.2481	+136.7451	....	+ 0.8	−28.6	0.6
121 to 120	0.599	214.905	+ 4.4438	+ 4.4472	+ 4.4455	+141.1906	....	− 3.4	−32.0	11.6
120 to 119	1.623	216.528	− 6.3476	− 6.3489	− 6.3482	+134.8424	....	+ 1.3	−30.7	1.7
119 to 118	1.327	217.855	− 1.2923	− 1.2921	− 1.2922	+133.5502	....	− 0.2	−30.9	0.0
118 to 117	2.512	220.367	− 5.2592	− 5.2546	− 5.2569	+128.2933	....	− 4.6	−35.5	21.2
117 to 116	1.862	222.229	− 1.7003	− 1.6974	− 1.6988	+126.5945	....	− 2.9	−38.4	8.4
116 to 115	2.792	225.021	− 1.9911	− 1.9973	− 1.9942	+124.6003	....	+ 6.2	−32.2	38.4
115 to 108	1.842	226.863	− 5.8094	− 5.8086	− 5.8090	+118.7913	....	− 0.8	−33.0	0.6
108 to 109	2.704	229.567	− 4.9810	− 4.9811	− 4.9811	+113.8102	....	+ 0.1	−32.9	0.0
109 to 110	1.106	230.673	−10.3835	−10.3881	−10.3858	+103.4244	....	+ 4.6	−28.3	21.2
110 to 111	2.655	233.328	−21.1712	−21.1664	−21.1688	+ 82.2556	....	− 4.8	−33.1	23.0
111 to J	1.550	234.878	− 1.7769	− 1.7782	− 1.7776	+ 80.4780	16.4	+ 1.3	−31.8	1.7
J to 128	1.243	236.121	+ 2.1501	+ 2.1528	+ 2.1515	+ 82.6295	....	− 2.7	−34.5	7.3
128 to 127	1.388	237.509	+ 3.2521	+ 3.2534	+ 3.2528	+ 85.8823	....	− 1.3	−35.8	1.7
127 to 126	3.152	240.661	+15.7920	+15.7930	+15.7925	+101.6748	....	− 1.0	−36.8	1.0
126 to 125	3.292	243.953	+ 3.5989	+ 3.5954	+ 3.5971	+105.2719	....	+ 3.5	−33.3	12.2
125 to 129	2.083	246.036	+ 3.6567	+ 3.6555	+ 3.6561	+108.9280	....	+ 1.2	−32.1	1.4
129 to 130	2.377	248.413	+ 7.0364	+ 7.0362	+ 7.0363	+115.9643	....	+ 0.2	−31.9	0.0
130 to 134	2.327	250.740	+ 4.2824	+ 4.2766	+ 4.2795	+120.2438	....	+ 5.8	−26.1	33.6
134 to XXIV	3.384	254.124	+11.6491	+11.6506	+11.6498	+131.8936	16.6	− 1.5	−27.6	2.2
XXIV to 135	0.514	254.638	+ 2.9866	+ 2.9898	+ 2.9882	+134.8818	....	− 3.2	−30.8	10.2
135 to 141	2.115	256.753	+ 9.6631	+ 9.6631	+ 9.6631	+144.5449	....	0.0	−30.8	0.0
141 to 142	2.175	258.928	− 3.7156	− 3.7128	− 3.7142	+140.8307	....	− 2.8	−33.6	7.8
142 to XXV	1.265	260.193	+ 6.5025	+ 6.5053	+ 6.5039	+147.3346	16.7	− 2.8	−36.4	7.8
XXV to 145	1.977	262.170	− 8.6919	− 8.6902	− 8.6910	+138.6436	....	− 1.7	−38.1	2.9
145 to 144	1.076	263.246	+ 2.3105	+ 2.3091	+ 2.3098	+140.9534	....	+ 1.4	−36.7	2.0
144 to 143	2.479	265.725	+ 5.5321	+ 5.5407	+ 5.5364	+146.4898	....	− 8.6	−45.3	74.0
143 to 140	2.458	268.183	+ 0.7733	+ 0.7706	+ 0.7720	+147.2618	....	+ 2.7	−42.6	7.3
140 to 139	0.974	269.157	− 3.4426	− 3.4468	− 3.4447	+143.8171	....	+ 4.2	−38.4	17.6
139 to 138	2.174	271.331	+ 5.8382	+ 5.8297	+ 5.8339	+149.6510	....	+ 8.5	−29.9	72.2
138 to 131	2.373	273.704	+ 2.5448	+ 2.5427	+ 2.5437	+152.1947	....	+ 2.1	−27.8	4.4
131 to 132	2.926	276.630	− 4.3516	− 4.3578	− 4.3547	+147.8400	....	+ 6.2	−21.6	38.4
132 to 133	1.385	278.015	− 1.9742	− 1.9713	− 1.9727	+145.8673	....	− 2.9	−24.5	8.4
133 to 136	1.821	279.836	− 4.1364	− 4.1390	− 4.1377	+141.7296	....	+ 2.6	−21.9	6.8
136 to 137	0.072	279.908	− 0.3026	− 0.3021	− 0.3023	+141.4273	....	− 0.5	−22.4	0.2
137 to K	0.190	280.098	+ 0.5485	+ 0.5468	+ 0.5476	+141.9749	17.5	+ 1.7	−20.7	2.9
137 to XXVI	0.416	280.324	+ 3.2367	+ 3.2364	+ 3.2365	+144.6638	17.5	+ 0.3	−22.1	0.1
137 to 148	1.953	281.861	+ 0.1393	+ 0.1374	+ 0.1383	+141.5656	....	+ 1.9	−20.5	3.6
148 to 147	2.965	284.826	− 4.9048	− 4.9057	− 4.9053	+136.6603	....	+ 0.9	−19.6	0.8
147 to 146	2.775	287.601	− 2.9135	− 2.9173	− 2.9154	+133.7449	....	+ 3.8	−15.8	14.4
146 to XXVII	2.009	289.610	−10.2271	−10.2192	−10.2231	+123.5218	17.7	− 7.9	−23.7	62.4
XXVII to 149	2.622	292.232	+ 7.4301	+ 7.4277	+ 7.4289	+130.9507	....	+ 2.4	−21.3	5.8
149 to 150	1.722	293.954	+ 6.0924	+ 6.0944	+ 6.0934	+137.0441	....	− 2.0	−23.3	4.0
150 to 151	1.336	295.290	+ 0.4227	+ 0.4233	+ 0.4230	+137.4671	....	− 0.6	−23.9	0.4
151 to 154	1.693	296.983	− 7.7427	− 7.7475	− 7.7451	+129.7220	....	+ 4.8	−19.1	23.0
154 to 153	3.082	300.065	− 9.3709	− 9.3719	− 9.3714	+120.3506	....	+ 1.0	−18.1	1.0
153 to 152	2.286	302.351	− 0.5319	− 0.5361	− 0.5340	+119.8166	....	+ 4.2	−13.9	17.6
152 to 155	2.697	305.048	− 6.7718	− 6.7812	− 6.7765	+113.0401	....	+ 9.4	− 4.5	88.4
155 to XXVIII	2.947	307.995	− 0.9659	− 0.9607	− 0.9633	+112.0768	18.2	− 5.2	− 9.7	27.0
XXVIII to 159	1.343	309.338	+ 5.1935	+ 5.1901	+ 5.1918	+117.2686	....	+ 3.4	− 6.3	11.6
159 to 158	1.642	310.980	+ 8.0906	+ 8.0949	+ 8.0928	+125.3614	....	− 4.3	−10.6	18.5
158 to 157	2.770	313.750	+ 5.1039	+ 5.1103	+ 5.1071	+130.4685	....	− 6.4	−17.0	41.0

Transcontinental line of Spirit-levels—Continued.

SECTION I.—FROM SANDY HOOK, N. J., TO HAGERSTOWN, MD.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod E, first line.	Rod F, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	$(mm)^2$
157 to 162	3.372	317.122	−16.4445	−16.4426	−16.4436	+114.0249	....	− 1.9	−18.9	3.6
162 to 156	4.297	321.419	−17.3639	−17.3619	−17.3629	+ 96.6620	....	− 2.0	−20.9	4.0
156 to XXIX	0.600	322.019	+12.0927	+12.0936	+12.0931	+108.7551	18.5	− 0.9	−21.8	0.8
XXIX to L	0.340	322.359	+ 3.2951	+ 3.2929	+ 3.2940	+112.0491	18.5	+ 2.2	−19.6	4.8
156 to 160	0.677	322.096	− 0.4216	− 0.4205	− 0.4211	+ 96.2409	....	− 1.1	−22.0	1.2
160 to 163	0.614	322.710	−0.5056 −0.5159 −0.5152 −0.5040	−0.5077 −0.5160 −0.5153 −0.5071*	− 0.5091	+ 95.7318	....	+ 1.3	−20.7	1.7
163 to 164	0.675	323.385	−0.3462 −0.3441 −0.3329	−0.3512 −0.3437 −0.3306†	− 0.3390	+ 95.3928	....	+ 0.7	−20.0	0.5
164 to 165	0.724	324.109	+13.9378	+13.9382	+13.9380	+109.3308	....	− 0.4	−20.4	0.2
165 to 169	2.551	326.660	+10.2388	+10.2332	+10.2360	+119.5668	....	+ 5.6	−14.8	31.4
169 to 166	3.603	330.263	+ 5.3357	+ 5.3386	+ 5.3372	+124.9040	....	− 2.9	−17.7	8.4
166 to 167	2.952	333.215	+ 8.1294	+ 8.1222	+ 8.1258	+133.0298	....	+ 7.2	−10.5	51.8
167 to 168	2.886	336.101	− 3.4626	− 3.4695	− 3.4660	+129.5638	....	+ 6.9	− 3.6	47.6
168 to 170	2.825	338.926	+ 1.0131	+ 1.0145	+ 1.0138	+130.5776	....	− 1.4	− 5.0	2.0
170 to 171	2.177	341.103	+ 3.4853	+ 3.4763	+ 3.4808	+134.0584	....	+ 9.0	+ 4.0	81.0
171 to 172	1.753	342.856	+ 4.7450	+ 4.7508	+ 4.7479	+138.8063	....	− 5.8	− 1.8	33.6
172 to 173	2.221	345.077	+ 0.1045	+ 0.1047	+ 0.1046	+138.9109	....	− 0.2	− 2.0	0.0
173 to 174	2.486	347.563	+ 3.7642	+ 3.7679	+ 3.7660	+142.6769	....	− 3.7	− 5.7	13.7
174 to 175	1.820	349.383	− 3.3149	− 2.3200	− 3.3175	+139.3594	....	+ 5.1	− 0.6	26.0
175 to M	1.847	351.230	+ 4.8750	+ 4.8740	+ 4.8745	+144.2339	19.4	+ 1.0	+ 0.4	1.0
M to 176	3.185	354.415	+ 0.4707	+ 0.4709	+ 0.4708	+144.7047	....	− 0.2	+ 0.2	0.0
176 to 177	2.809	357.224	− 5.7601	− 5.7716	− 5.7658	+138.9389	....	+11.5	+11.7	132.2
177 to 178	2.482	359.706	+15.7487	+15.7440	+15.7464	+154.6853	....	+ 4.7	+16.4	22.1
178 to 179	2.641	362.347	− 3.5971	− 3.5994	− 3.5983	+151.0870	....	+ 2.3	+18.7	5.3
179 to 182	3.108	365.455	+11.0716	+11.0648	+11.0682	+162.1552	....	+ 6.8	+25.5	46.2
182 to 181	2.149	367.604	− 0.6150	− 0.6153	− 0.6152	+161.5400	....	+ 0.3	+25.8	0.1
181 to 180	2.867	370.471	− 0.6354	− 0.6347	− 0.6351	+160.9049	....	− 0.7	+25.1	0.5
180 to 193	2.735	373.206	+15.6064	+15.6063	+15.6064	+176.5113	....	+ 0.1	+25.2	0.0
193 to 194	2.904	376.110	− 5.4378	− 5.4398	− 5.4388	+171.0725	....	+ 2.0	+27.2	4.0
194 to 188	2.633	378.743	+ 7.8495	+ 7.8514	+ 7.8504	+178.9229	....	− 1.9	+25.3	3.6
188 to 187	1.975	380.718	+ 1.9435	+ 1.9497	+ 1.9466	+180.8695	....	− 6.2	+19.1	38.4
187 to 186	2.053	382.771	+ 9.6586	+ 9.6565	+ 9.6575	+190.5270	....	+ 2.1	+21.2	4.4
186 to 185	2.322	385.093	+ 8.4885	+ 8.4958	+ 8.4922	+199.0192	....	− 7.3	+13.9	53.3
185 to 184	1.397	386.490	+ 1.3915	+ 1.3898	+ 1.3907	+200.4099	....	+ 1.7	+15.6	2.9
184 to 183	1.340	387.830	− 1.6236	− 1.6282	− 1.6259	+198.7840	....	+ 4.6	+20.2	21.2
183 to XXX	0.181	388.011	+ 0.5368	+ 0.5365	+ 0.5366	+199.3206	20.4	+ 0.3	+20.5	0.1
183 to 192	2.339	390.169	+13.7796	+13.7826	+13.7811	+212.5651	....	− 3.0	+17.2	9.0
192 to 191	2.769	392.938	+17.2464	+17.2461	+17.2462	+229.8113	....	+ 0.3	+17.5	0.1
191 to 190	3.372	396.310	− 6.8102	− 6.8180	− 6.8141	+222.9972	....	+ 7.8	+25.3	60.8
190 to 189	2.085	398.395	−12.6775	−12.6759	−12.6767	+210.3205	....	− 1.6	+23.7	2.6
189 to 195	3.721	402.116	− 3.1371	− 3.1303	− 3.1337	+207.1868	....	− 6.8	+16.9	46.2
195 to 196	2.517	404.633	−15.8293	−15.8334	−15.8314	+191.3554	....	+ 4.1	+21.0	16.8
196 to 197	1.465	406.098	+ 0.8022	+ 0.8063	+ 0.8043	+192.1597	....	− 4.1	+16.9	16.8
197 to N	0.578	406.676	− 2.9933	− 2.9927	− 2.9930	+189.1667	20.8	− 0.6	+16.3	0.4
197 to 198	2.687	408.785	− 5.0741	− 5.0813	− 5.0777	+187.0820	....	+ 7.2	+24.1	51.8
198 to 199	2.993	411.778	+ 6.7928	+ 6.7956	+ 6.7942	+193.8762	....	− 2.8	+21.3	7.8
199 to 200	3.351	415.129	+ 0.5389	+ 0.5378	+ 0.5384	+194.4146	....	+ 1.1	+22.4	1.2
200 to 201	1.151	416.280	− 1.1972	− 1.2023	− 1.1998	+193.2148	....	+ 5.1	+27.5	26.0
201 to 209	3.606	419.886	−16.0136	−16.0178	−16.0157	+177.1991	....	+ 4.2	+31.7	17.6
209 to 205	3.175	423.061	+ 3.0184	+ 3.0158	+ 3.0171	+180.2162	....	+ 2.6	+34.3	6.8

* Weight 3. † Weight 2.

Transcontinental line of Spirit-levels—Continued.

SECTION I.—FROM SANDY HOOK, N. J., TO HAGERSTOWN, MD.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks.			Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy.		Δ^2
			Rod E, first line.	Rod F, second line.	Mean.			Partial Δ	Total.	
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	(*mm*)²
205 to XXXI	0.272	423.333	− 0.7987	− 0.8010	− 0.7999	+179.4163	21.1	+ 2.3	+36.6	5.3
205 to 206	2.500	425.561	− 9.0881	− 9.0956	− 9.0919	+171.1243	....	+ 7.5	+41.8	56.2
206 to 207	2.469	428.030	− 1.4737	− 1.4709	− 1.4723	+169.6520	....	− 2.8	+39.0	7.8
207 to 208	2.667	430.697	+ 2.3448	+ 2.3439	+ 2.3444	+171.9964	....	+ 0.9	+39.9	0.8
208 to 204	3.177	433.874	+ 5.8335	+ 5.8341	+ 5.8338	+177.8302	....	− 0.6	+39.3	0.4
204 to 203	1.048	434.922	+ 7.4887	+ 7.4917	+ 7.4902	+185.3204	....	− 3.0	+36.3	9.0
203 to 202	3.321	438.243	+ 9.5128	+ 9.5209	+ 9.5169	+194.8373	....	− 8.1	+28.2	65.6
202 to A	3.129	441.372	−26.4940	−26.5002	−26.4971	+168.3402	21.6	+ 6.2	+34.4	38.4

SECTION I.—*Descriptions of primary and secondary bench-marks between Sandy Hook, N. J., and Hagerstown, Md.*

T. H.—A heavy line on the northwest corner post, inside the tide-house at Sandy Hook. It is the starting-point of the line of levels.

No. I—The centre of the inner edge of the second embrasure, southwest corner of the fort at Sandy Hook.

A & B—Sandy Hook, are cedar posts 4 feet long and 8 inches in diameter, sunk in the ground with ends projecting about 4 inches. In the centre of each post is a copper nail surrounded by five others in form of a pentagon. These posts are 12 metres apart and bear east-northeast from the steamer-landing and nearly northeast from the tide-house, and are distant from the latter about 500 metres. They are also 95 metres northwest of the railroad red engine-house, and are in the edge of the cedars, where the ground is elevated a few feet above the marsh.

C.—A cross on the head of a copper bolt inserted in the wall of the main light-house tower at Sandy Hook. It is a few inches west of the northwest angle of the tower and 9¼ inches above the sloping ledge near its base.

No. II—A heavy granite post which projects about 2 feet above the surface of the ground, on the east side of the track of the New Jersey Southern Railroad about three-fourths mile north of Highland Station.

No. III—Navesink Highlands. A mark on top of a heavy granite post, 13 metres south of the southernmost light-house tower.

D—Navesink Highlands light-house. The bottom surface of a square cavity cut on the sloping ledge at the southeast corner of the base of the southernmost tower.

No. IV—Seabright, N. J. The bottom surface of a square cavity cut on the north wing-wall of the west abutment of the bridge over South Shrewsbury River.

No. V—A square cavity cut on the south pier of the "Oceanport Drawbridge," about 1½ miles north of Branchport Station, New Jersey Central Railroad.

E—Red Bank, N. J. A marble post near the southeast corner of the house of Rev. B. F. Leipser. The house stands on southwest corner of Monmouth and Pearl streets.

No. VI—Matawan, N. J. The centre of a triangle cut on a flagstone in front of Benjamin Tuttle's house, on Main street.

No. VII—Morgan Station, New Jersey Central Railroad, N. J. The centre of a triangle cut on the southeast pier of the drawbridge over Cheesequake Creek.

No. VIII—The centre of a triangle cut on stone wall at crossing of Camden and Amboy branch of Pennsylvania Railroad and New Jersey Central Railroad, near South Amboy.

F—The bottom surface of a square cavity cut on the pier at the north end of drawbridge, Raritan Bay. It is marked thus:

F
B □ M
U. S. C. & G. S.
1881

No. IX—A slight circular concavity, bounded by a triangle, cut on the west end of the south wall of stone bridge near Metuchen's Tank Station of Lehigh Valley Railroad. By means of this bridge the Pennsylvania Railroad crosses the Lehigh Valley Railroad.

No. X—A square cavity marked thus: B □ M, cut on stone abutment at the northwest corner of a small iron railroad bridge, about 150 metres east of South Plainfield Station, Lehigh Valley Railroad.

No. XI—Cut on northeast corner of stone abutment of railroad bridge (New Jersey Central Railroad) about one-fourth mile east of Bound Brook, N. J. It is marked thus: B □ M.

No. XII—Cut on the south end of a small railroad bridge, about three-fourths mile west of New Market Station, Lehigh Valley Railroad. It is marked thus:

B □ M
XII

No. XIII—A square cavity cut on top of the west end of the north abutment of road bridge over Raritan River and Canal at Bound Brook, N. J. It is marked thus: B □ M.

No. XIV—The bottom surface of a circular cavity in top of a granite monument (True Meridian Monument of the State Survey) in the grounds of the court-house at Somerville, N. J.

G—A square cavity cut in the stone at the base of the easternmost pillar of the court-house front, at Somerville, N. J. It is marked thus:

G
B □ M
U. S. C. & G. S.
1881.

No. XV—Cut on the southwest corner of the railroad bridge over the north branch of the Raritan River, near North Branch Station, New Jersey Central Railroad. It is marked:

B □ M
XV

No. XVI—Cut on projecting stone near the centre of the north abutment wall of overhead bridge, about one mile east of Annandale, N. J.

No. XVII—One-fourth mile west of Bloomsbury, N. J., on the northwest corner of a stone bridge (New Jersey Central Railroad) over wagon road. It is marked thus:

B □ M
1881

No. XVIII—Cut on coping stone at east end of the north parapet of New Jersey Central Railroad bridge over the Delaware and Lackawanna Canal, 1½ miles east of Phillipsburg, N. J. It is marked the same as No. XVII.

No. XIX—Easton, Pa. Cut on one of the central piers of the railroad bridge across the Lehigh River. It is marked thus:

U. S.
B □ M
XIX.

No. XX—Cut on foundation stone at the west corner of the jail at Easton, Pa. It is marked thus:

U. S.
B □ M
XX

H—Easton, Pa. The sill of a blind window on east side of the court-house. It is marked thus:

H
U. S. C. & G. S.
B □ M
1881.

I—Allentown, Pa. Cut on the sill of a basement window, on the south side of the front entrance of the jail. It is marked thus:

I
U. S. C. & G. S.
B □ M
1881.

No. XXI—About 1½ miles west of Allentown, Pa. It is cut on the northeast corner of a bridge (Philadelphia and Reading Railroad) over a wagon road. It is marked B □ M.

No. XXII—Cut on the top stone of the middle of the north side of a bridge (Philadelphia and Reading Railroad) over a small run, about one-half mile west of Macungie Station. It is marked thus:

XXII
B □ M
1881.

J—Reading, Pa. Cut on the coping stone of the eastern abutment of the northeasternmost railroad bridge at the railroad depot. It is marked thus:

J
U. S. C. & G. S.
B □ M
1881.

No. XXIII—About one-fourth mile east of Shamrock Station, Philadelphia and Reading Railroad. Cut on the southeast corner of a railroad bridge. It is marked thus: B □ M.

No. XXIV—About one-eighth mile east of Robesonia Station, Philadelphia and Reading Railroad. Cut on a pier of a small bridge. It is marked thus:

XXIV
B □ M
1881.

No. XXV—Cut at the east end of the base of the north wall of an overhead bridge, about 1½ miles west of Womelsdorf Station, Philadelphia and Reading Railroad. It is marked thus:

XXV
B □ M
1881.

No. XXVI—The centre of the cross, on a white marble block, built into the front wall of Saint Mary's Catholic Church, at Lebanon, Pa., at the south side of the southernmost front entrance.

K—The bottom of a square cavity, in the top of a marble post, in the grounds of Mr. P. L. Weiner, southeast corner of Eighth and Church streets, Lebanon, Pa. The top of the post is marked:

U. S.
□
B. M.

and its south face bears the letter K.

No. XXVII—At the southwest corner of the bridge (Philadelphia and Reading Railroad) over "Joe Crider's Dam," about 1¼ miles west of Annville, Lebanon County, Pennsylvania. It is marked thus:

XXVII
B □ M
1881

No. XXVIII—Cut on stone parapet of the bridge over Swatara River and Canal, between Beaver and Hummelstown Stations (Philadelphia and Reading Railroad.) It is marked thus:

XXVIII
B □ M
1881

No. XXIX—Harrisburg, Pa. The centre of the top surface of the monument (in the capitol grounds) marking the astronomical station of the Coast and Geodetic Survey.

L—Cut at the base of the pillar at the southeast corner of the capitol building, Harrisburg, Pa., and is marked thus:

L
U. S. C. & G. S.
B □ M
1881.

M—Carlisle, Pa. Cut on the base of the column, at the west side of the jail entrance. It is marked thus:

M
U. S. C. & G. S.
B □ M
1881

No. XXX—Shippensburg, Pa. Cut on the water-table of the house and store of Mr. C. J. Reddig, northwest corner of Main and Railroad streets. It is marked thus: B □ M.

N—Cut on the pedestal, at base of the northernmost pillar of the front of the court-house at Chambersburg, Pa. It is marked thus:

N
U. S. C. & G. S.
B □ M
1881.

No. XXXI—Greencastle, Pa. The centre of a cross, cut in a stone in the front wall of the Philadelphia and Reading Railroad depot. It is south of the entrance and seven inches above the level of the sidewalk.

A—Hagerstown, Md. Cut on the water-table of the court-house, which stands at the corner of Washington and Jonathan streets. The bench-mark is on the Jonathan street side. It is marked thus:

A
B □ M
U. S. C. S.
Oct. 1877.

Transcontinental line of Spirit-levels—Continued.

SECTION II.—FROM HAGERSTOWN, MD., TO GRAFTON, W. VA.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod A, first line.	Rod B, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ.	Total.	
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	$(mm.)^2$
A	....	441.372	....	....	....	+168.3402	21.6	....	+34.4	....
A to 1	0.566	441.938	− 0.4735	− 0.4726	− 0.4730	+167.8672	....	− 0.9	+33.5	0.8
1 to I	1.198	443.136	+ 3.9905	+ 3.9914	+ 3.9909	+171.8581	21.6	− 0.9	+32.6	0.8
I to 3	1.043	444.179	+ 7.7253	+ 7.7268	+ 7.7260	+179.5841	....	− 1.5	+31.1	2.2
3 to II	0.716	444.895	− 2.5639	− 2.5639	− 2.5639	+177.0202	21.6	0.0	+31.1	0.0
II to 4	1.623	446.518	+ 1.1564	+ 1.1633	+ 1.1599	+178.1801	....	− 6.9	+24.2	47.6
4 to 5	0.627	447.145	−15.6442	−15.6483	−15.6463	+162.5338	....	+ 4.1	+28.3	16.8
5 to IV	0.987	448.132	−11.7305	−11.7296	−11.7300	+150.8038	21.7	− 0.9	+27.4	0.8
IV to 6	0.271	448.403	+ 4.0371	+ 4.0364	+ 4.0367	+154.8405	....	+ 0.7	+28.1	0.5
6 to 7	0.567	448.970	− 5.1413	− 5.1403	− 5.1408	+149.6997	....	− 1.0	+27.1	1.0
7 to 8	0.585	449.555	− 5.1227	− 5.1230	− 5.1228	+144.5769	....	+ 0.3	+27.4	0.1
8 to V	0.194	449.749	− 8.1843	− 8.1822	− 8.1833	+136.3936	21.7	− 2.1	+25.3	4.4
V to 9	1.426	451.175	− 4.8648	− 4.8661	− 4.8654	+131.5282	....	+ 1.3	+26.6	1.7
9 to 11	0.456	451.631	− 7.0137	− 7.0122	− 7.0130	+124.5152	....	− 1.5	+25.1	2.3
11 to 12	0.392	452.023	− 9.5686	− 9.5689	− 9.5687	+114.9465	....	+ 0.3	+25.4	0.1
12 to 13	0.137	452.160	− 5.7244	− 5.7248	− 5.7246	+109.2219	....	+ 0.4	+25.8	0.2
13 to B	0.248	452.408	− 0.1036	− 0.1035	− 0.1036	+109.1183	21.8	− 0.1	+25.7	0.0
B to 14	1.253	453.661	+ 0.1406	+ 0.1353	+ 0.1380	+109.2563	....	+ 5.3	+31.0	28.1
14 to 15	1.381	455.042	− 0.1286	− 0.1283	− 0.1285	+109.1278	....	− 0.3	+30.7	0.1
15 to 16	0.741	455.783	− 0.0574	− 0.0551	− 0.0562	+109.0716	....	− 2.3	+28.4	5.3
16 to 17	1.018	456.801	− 0.0035	− 0.0034	− 0.0035	+109.0681	....	− 0.1	+28.3	0.0
17 to 18	1.021	457.822	− 0.2061	− 0.2110	− 0.2085	+108.8596	....	+ 4.9	+33.2	24.0
18 to 19	0.929	458.751	+ 0.0090	+ 0.0129	+ 0.0109	+108.8705	....	− 3.9	+29.3	15.2
19 to 20	1.138	459.889	+ 0.2207	+ 0.2187	+ 0.2197	+109.0902	....	+ 2.0	+31.3	4.0
20 to 21	0.900	460.789	− 0.0592	− 0.0569	− 0.0581	+109.0321	....	− 2.3	+29.0	5.3
21 to 22	1.825	462.614	+ 0.1171	+ 0.1172	+ 0.1172	+100.1493	....	− 0.1	+28.9	0.0
22 to 23	0.268	462.882	+ 0.4856	+ 0.4868	+ 0.4862	+109.6355	....	− 1.2	+27.7	1.4
23 to C	0.764	463.646	+ 3.7106	+ 3.7075	+ 3.7090	+113.3445	22.0	+ 3.1	+30.8	9.6
C to 24	0.479	464.125	− 1.0881	− 1.0867	− 1.0874	+112.2571	....	− 1.4	+29.4	2.0
24 to VI	0.592	464.717	+ 1.0021	+ 1.0063	+ 1.0042	+113.2613	22.0	− 4.2	+25.2	17.6
VI to 25	0.359	465.076	+ 0.3310	+ 0.3307	+ 0.3309	+113.5922	....	+ 0.3	+25.5	0.1
25 to 26	1.480	466.556	− 0.4139	− 0.4121	− 0.4130	+113.1792	....	− 1.8	+23.7	3.2
26 to D	0.617	467.173	+10.1046	+10.1033	+10.1040	+123.2832	22.1	+ 1.3	+25.0	1.7
D to 27	1.060	468.233	− 0.0404	− 0.0375	− 0.0390	+123.2422	....	− 2.9	+22.1	8.4
27 to 28	0.898	469.131	+ 0.1460	+ 0.1436	+ 0.1448	+123.3870	....	+ 2.4	+24.5	5.8
28 to 29	1.382	470.513	+ 0.0525	+ 0.0502	+ 0.0514	+123.4384	....	+ 2.3	+26.8	5.3
29 to 30	1.663	472.176	− 0.2555	− 0.2589	− 0.2572	+123.1812	....	+ 3.4	+30.2	11.6
30 to 31	1.333	473.509	+ 0.2285	+ 0.2326	+ 0.2305	+123.4117	....	− 4.1	+26.1	16.8
31 to VII	0.588	474.097	+ 0.2449	+ 0.2443	+ 0.2446	+123.6563	22.2	+ 0.6	+26.7	0.4
VII to 32	1.579	475.676	− 0.0172	− 0.0169	− 0.0170	+123.6393	....	− 0.3	+26.4	0.1
32 to 33	1.360	477.036	− 0.0695	− 0.0714	− 0.0705	+123.5688	....	+ 1.9	+28.3	3.6
33 to 34	1.354	478.390	− 0.1080	− 0.1073	− 0.1076	+123.4612	....	− 0.7	+27.6	0.5
34 to E	0.811	479.201	− 0.0682	− 0.0642	− 0.0662	+123.3950	22.2	− 4.0	+23.6	16.0
E to 35	1.698	480.899	+ 0.2246	+ 0.2192	+ 0.2219	+123.6169	....	+ 5.4	+29.0	29.2
35 to 36	1.105	482.004	+ 0.0128	+ 0.0135	+ 0.0131	+123.6300	....	− 0.7	+28.3	0.5
36 to 38	1.572	483.576	− 0.2338	− 0.2315	− 0.2326	+123.3974	....	− 2.3	+26.0	5.3
38 to 39	0.819	484.395	+ 0.2057	+ 0.2095	+ 0.2076	+123.6050	....	− 3.8	+22.2	14.4
39 to 40	1.947	486.342	− 0.5674	− 0.5704	− 0.5689	+123.0361	....	+ 3.0	+25.2	9.0
40 to 41	1.233	487.575	+ 0.5719	+ 0.5744	+ 0.5731	+123.6092	....	− 2.5	+22.7	6.2
41 to 42	1.392	488.967	− 0.0784	− 0.0842	− 0.0813	+123.5279	....	+ 5.8	+28.5	33.6
42 to VIII	0.888	489.855	+ 4.0097	+ 4.0078	+ 4.0088	+127.5367	22.5	+ 1.9	+30.4	3.6
VIII to F	1.689	491.544	+ 0.7553	+ 0.7615	+ 0.7584	+128.2951	22.6	− 6.2	+24.2	38.4
F to 43	0.709	492.253	+ 0.0319	+ 0.0356	+ 0.0337	+128.3288	....	− 3.7	+20.5	13.7
43 to 44	1.384	493.637	+ 0.1647	+ 0.1654	+ 0.1651	+128.4939	....	− 0.7	+19.8	0.5
44 to 45	1.366	495.003	− 1.2581	− 1.2609	− 1.2595	+127.2344	....	+ 2.8	+22.6	7.8
45 to 46	0.917	495.920	+ 1.2802	+ 1.2794	+ 1.2798	+128.5142	....	+ 0.8	+23.4	0.6
46 to 47	1.134	497.054	+ 0.1621	+ 0.1586	+ 0.1603	+128.6745	....	+ 3.5	+26.9	12.3

Transcontinental line of Spirit-levels—Continued.

SECTION II.—FROM HAGERSTOWN, MD., TO GRAFTON, W. VA.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod A, first line.	Rod B, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	$(mm.)^2$
47 to 48	1.215	498.269	− 0.0732	− 0.0705	− 0.0718	+128.6027	....	− 2.7	+24.2	7.3
48 to 49	1.548	499.817	+ 0.3720	+ 0.3653	+ 0.3686	+128.9713	....	+ 6.7	+30.9	44.9
49 to IX	1.461	501.278	+ 1.2537	+ 1.2534	+ 1.2536	+130.2249	22.8	+ 0.3	+31.2	0.1
IX to 50	0.900	502.178	+ 0.5224	+ 0.5230	+ 0.5227	+130.7476	....	− 0.6	+30.6	0.4
50 to 51	1.562	503.740	− 0.2117	− 0.2109	− 0.2113	+130.5363	....	− 0.8	+29.8	0.6
51 to 52	1.301	505.041	+ 0.3728	+ 0.3691	+ 0.3709	+130.9072	....	+ 3.7	+33.5	13.7
52 to 53	1.498	506.539	+ 0.3134	+ 0.3135	+ 0.3135	+131.2207	....	− 0.1	+33.4	0.0
53 to G	1.308	507.847	+ 4.1005	+ 4.0999	+ 4.1002	+135.3209	22.8	+ 0.6	+34.0	0.4
G to 54	1.589	509.436	+ 0.4053	+ 0.4090	+ 0.4071	+135.7280	....	− 3.7	+30.3	13.7
54 to 55	0.895	510.331	− 0.2223	− 0.2214	− 0.2218	+135.5062	....	− 0.9	+29.4	0.8
55 to X	1.022	511.353	+ 2.1921	+ 2.1904	+ 2.1912	+137.6974	22.9	+ 1.7	+31.1	2.9
X to 56	1.965	513.318	+ 0.1240	+ 0.1217	+ 0.1229	+137.8203	....	+ 2.3	+33.4	5.3
56 to 57	0.960	514.278	+ 0.2818	+ 0.2842	+ 0.2830	+138.1033	....	− 2.4	+31.0	5.8
57 to 58	1.600	515.878	+ 0.2801	+ 0.2779	+ 0.2790	+138.3823	....	+ 2.2	+33.2	4.8
58 to XI	0.246	516.124	+ 1.2980	+ 1.2972	+ 1.2976	+139.6799	22.9	+ 0.8	+34.0	0.6
XI to 59	0.903	517.027	+ 0.7870	+ 0.7870	+ 0.7870	+140.4669	....	0.0	+34.0	0.0
59 to XII	1.803	518.830	− 0.3178	− 0.3157	− 0.3168	+140.1501	22.9	− 2.1	+31.9	4.4
XII to 60	1.203	520.033	+ 0.0029	+ 0.0024	+ 0.0027	+140.1528	....	+ 0.5	+32.4	0.2
60 to 61	1.634	521.667	+ 0.7359	+ 0.7370	+ 0.7364	+140.8892	....	− 1.1	+31.3	1.2
61 to XIII	2.045	523.712	+ 1.6695	+ 1.6699	+ 1.6697	+142.5589	23.0	− 0.4	+30.9	0.2
XIII to 62	1.308	525.020	− 0.0249	− 0.0254	− 0.0251	+142.5338	....	+ 0.5	+31.4	0.2
62 to 63	1.718	526.738	+ 0.4618	+ 0.4592	+ 0.4605	+142.9943	....	+ 2.6	+34.0	6.8
63 to 64	1.570	528.308	+ 2.0753	+ 2.0755	+ 2.0754	+145.0697	....	− 0.2	+33.8	0.0
64 to 65	2.055	530.363	+ 0.3511	+ 0.3524	+ 0.3517	+145.4214	....	− 1.3	+32.5	1.7
65 to 66	1.622	531.985	− 0.7265	− 0.7283	− 0.7274	+144.6940	....	+ 1.8	+34.3	3.2
66 to 67	1.529	533.514	+ 2.9832	+ 2.9835	+ 2.9834	+147.6774	....	− 0.3	+34.0	0.1
67 to 68	1.911	535.425	+ 0.2570	+ 0.2524	+ 0.2547	+147.9321	....	+ 4.6	+38.6	21.2
68 to 69	1.517	536.942	− 0.2210	− 0.2229	− 0.2220	+147.7101	....	+ 1.9	+40.5	3.6
69 to H	1.334	538.276	+ 2.3656	+ 2.3686	+ 2.3671	+150.0772	23.1	− 3.0	+37.5	9.0
H to 70	1.944	540.220	+ 3.3000	+ 3.2970	+ 3.2985	+153.3757	....	+ 3.0	+40.5	9.0
70 to 71	0.414	540.634	+ 4.7588	+ 4.7567	+ 4.7577	+158.1334	....	+ 2.1	+42.6	4.4
71 to 72	0.896	541.530	+ 4.7058	+ 4.7025	+ 4.7042	+162.8376	....	+ 3.3	+45.9	10.9
72 to XIV	0.099	541.629	− 0.5564	− 0.5568	− 0.5566	+162.2810	23.1	+ 0.4	+46.3	0.2
XIV to 73	0.957	542.586	+ 0.5349	+ 0.5349	+ 0.5349	+162.8159	....	0.0	+46.3	0.0
73 to 74	1.452	544.038	− 0.3372	− 0.3357	− 0.3365	+162.4794	....	− 1.5	+44.8	2.2
74 to 75	1.671	545.709	− 0.1526	− 0.1503	− 0.1514	+162.3280	....	− 2.3	+42.5	5.3
75 to 76	1.587	547.296	+ 0.3824	+ 0.3809	+ 0.3816	+162.7096	....	+ 1.5	+44.0	2.3
76 to 77	1.315	548.611	− 0.1780	− 0.1764	− 0.1772	+162.5324	....	− 1.6	+42.4	2.6
77 to 78	1.895	550.506	− 0.2396	− 0.2376	− 0.2386	+162.2938	....	− 2.0	+40.4	4.0
78 to 79	0.307	550.813	+ 0.4421	+ 0.4425	+ 0.4423	+162.7361	....	− 0.4	+40.0	0.2
79 to XV	1.336	552.149	+ 1.9889	+ 1.9819	+ 1.9854	+164.7215	23.3	+ 7.0	+47.0	49.0
XV to 80	1.689	553.838	+ 0.2443	+ 0.2499	+ 0.2471	+164.9686	....	− 5.6	+41.4	31.4
80 to 81	1.865	555.703	+ 1.0625	+ 1.0590	+ 1.0608	+166.0294	....	+ 3.5	+44.9	12.2
81 to 82	1.513	557.216	+ 1.2019	+ 1.1996	+ 1.2007	+167.2301	....	+ 2.3	+47.2	5.3
82 to 83	2.044	559.260	+ 0.0104	+ 0.0139	+ 0.0122	+167.2423	....	− 3.5	+43.7	12.3
83 to 84	1.331	560.591	+ 5.1768	+ 5.1729	+ 5.1748	+172.4171	....	+ 3.9	+47.6	15.2
84 to 85	2.749	563.340	+ 2.3589	+ 2.3615	+ 2.3602	+174.7773	....	− 2.6	+45.0	6.8
85 to 86	0.564	563.904	− 0.0092	− 0.0080	− 0.0086	+174.7687	....	− 1.2	+43.8	1.4
86 to 87	1.945	565.849	− 0.1307	− 0.1268	− 0.1287	+174.6400	....	− 3.9	+39.9	15.2
87 to 88	1.069	566.918	+ 0.1057	+ 0.1074	+ 0.1065	+174.7465	....	− 2.7	+37.2	7.3
88 to 89	1.657	568.575	+ 0.0200	+ 0.0203	+ 0.0202	+174.7667	....	− 0.3	+36.9	0.1
89 to 90	1.487	570.062	− 0.1989	− 0.2052	− 0.2021	+174.5646	....	+ 6.3	+43.2	39.7
90 to 91	1.764	571.826	+ 0.1927	+ 0.1905	+ 0.1916	+174.7562	....	+ 2.2	+45.4	4.8
91 to 92	1.504	573.330	+ 2.7870	+ 2.7887	+ 2.7879	+177.5441	....	− 1.7	+43.7	2.9
92 to 93	0.256	573.586	− 0.1348	− 0.1351	− 0.1350	+177.4091	....	+ 0.3	+44.0	0.1
93 to XVI	0.676	574.262	+ 1.7064	+ 1.7042	+ 1.7053	+179.1144	23.7	+ 2.2	+46.2	4.8
XVI to 94	0.185	574.447	+ 2.8076	+ 2.8057	+ 2.8067	+181.9211	....	+ 1.9	+48.1	3.6

Transcontinental line of Spirit-levels—Continued.

SECTION II.—FROM HAGERSTOWN, MD., TO GRAFTON, W. VA.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod A, first line.	Rod B, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	$(mm.)^2$
94 to 95	0.107	574.554	+ 2.9419	+ 2.9409	+ 2.9414	+184.8625	....	+ 1.0	+49.1	1.0
95 to 96	2.331	576.885	+ 1.6793	+ 1.6788	+ 1.6790	+186.5415	....	+ 0.5	+49.6	0.2
96 to 97	0.848	577.733	− 0.1740	− 0.1727	− 0.1733	+186.3682	....	− 1.3	+48.3	1.7
97 to 98	2.424	580.157	+ 0.0072	+ 0.0074	+ 0.0073	+186.3755	....	− 0.2	+48.1	0.0
98 to 99	0.570	580.727	− 0.0724	− 0.0780	− 0.0752	+186.3003	....	+ 5.6	+53.7	31.4
99 to 100	1.875	582.602	+ 0.0743	+ 0.0744	+ 0.0743	+186.3746	....	− 0.1	+53.6	0.0
100 to 101	0.317	582.919	+ 0.0513	+ 0.0515	+ 0.0514	+186.4260	....	− 0.2	+53.4	0.0
101 to 102	1.482	584.401	+ 1.5330	+ 1.5329	+ 1.5330	+187.9590	....	+ 0.1	+53.5	0.0
102 to I	1.133	585.534	+ 2.1457	+ 2.1469	+ 2.1463	+190.1053	23.8	− 1.2	+52.3	1.4
I to 103	1.247	586.781	+ 2.8642	+ 2.8602	+ 2.8622	+192.9675	....	+ 4.0	+56.3	16.0
103 to 104	0.267	587.048	− 1.6519	− 1.6484	− 1.6502	+191.3173	....	− 3.5	+52.8	12.2
104 to 105	2.637	589.685	+ 1.5553	+ 1.5572	+ 1.5563	+192.8736	....	− 1.9	+50.9	3.6
105 to 106	1.682	591.367	+ 1.9943	+ 1.9951	+ 1.9947	+194.8683	....	− 0.8	+50.1	0.6
106 to 107	1.734	593.101	+ 2.8240	+ 2.8214	+ 2.8227	+197.6910	....	+ 2.6	+52.7	6.8
107 to XVII	1.422	594.523	− 0.3732	− 0.3735	− 0.3734	+197.3176	23.9	+ 0.3	+53.0	0.1
XVII to 108	1.156	595.679	+ 3.9592	+ 3.9567	+ 3.9580	+201.2756	....	+ 2.5	+55.5	6.3
108 to 109	1.538	597.217	+ 0.6937	+ 0.6951	+ 0.6944	+201.9700	....	− 1.4	+54.1	2.0
109 to 110	1.358	598.575	+ 5.0048	+ 5.0077	+ 5.0062	+206.9762	....	− 2.9	+51.2	8.4
110 to 111	1.426	600.001	− 0.7084	− 0.7126	− 0.7105	+206.2657	....	+ 4.2	+55.4	17.6
111 to 112	1.624	601.625	+ 0.0020	+ 0.0019	+ 0.0020	+206.2677	....	+ 0.1	+55.5	0.0
112 to 113	1.452	603.077	+ 2.7360	+ 2.7347	+ 2.7353	+209.0030	....	+ 1.5	+56.8	1.7
113 to XVIII	0.725	603.802	+ 2.5289	+ 2.5291	+ 2.5290	+211.5320	23.9	− 0.2	+56.6	0.0
XVIII to 115	2.288	606.090	+ 3.4140	+ 3.4117	+ 3.4129	+214.9449	....	+ 2.3	+58.9	5.3
115 to 116	0.963	607.053	+ 2.3147	+ 2.3147	+ 2.3147	+217.2596	....	0.0	+58.9	0.0
116 to 117	0.390	607.443	+ 0.3438	+ 0.3432	+ 0.3435	+217.6031	....	+ 0.6	+59.5	0.4
117 to 118	1.565	609.008	+ 2.0632	+ 2.0652	+ 2.0642	+219.6673	....	− 2.0	+57.5	4.0
118 to 119	1.910	610.918	+ 5.7194	+ 5.7180	+ 5.7187	+225.3860	....	+ 1.4	+58.9	2.0
119 to 120	1.688	612.606	+ 3.1739	+ 3.1699	+ 3.1719	+228.5579	....	+ 4.0	+62.9	16.0
120 to 121	1.153	613.759	+ 1.0672	+ 1.0616	+ 1.0644	+229.6223	....	+ 5.6	+68.5	31.4
121 to XIX	1.862	615.621	+ 4.2780	+ 4.2736	+ 4.2758	+233.8981	24.1	+ 4.4	+72.9	19.4
XIX to 122	1.408	617.029	+ 2.9328	+ 2.9267	+ 2.9297	+236.8278	....	+ 6.1	+79.0	37.2
122 to 123	2.317	619.346	+ 4.9722	+ 4.9725	+ 4.9724	+241.8002	....	− 0.3	+78.7	0.1
123 to 124	1.542	620.888	+ 2.2438	+ 2.2436	+ 2.2437	+244.0439	....	+ 0.2	+78.9	0.0
124 to 125	0.327	621.215	+ 0.6686	+ 0.6689	+ 0.6687	+244.7126	....	− 0.3	+78.6	0.0
125 to J	0.215	621.430	+ 0.0113	+ 0.0138	+ 0.0126	+244.7252	24.2	− 2.5	+76.1	6.2
J to 126	1.793	623.223	+ 7.9878	+ 7.9937	+ 7.9907	+252.7159	....	− 5.9	+70.2	34.8
126 to 127	1.607	624.830	+ 3.4980	+ 3.5094	+ 3.5037	+256.2196	....	−11.4	+58.8	130.0
127 to 128	1.647	626.477	+ 6.3315	+ 6.3356	+ 6.3336	+262.5532	....	− 4.1	+54.7	16.8
128 to 129	1.753	628.230	+ 7.6956	+ 7.6894	+ 7.6925	+270.2457	....	+ 6.2	+60.9	38.4
129 to 130	1.670	629.900	+ 8.6968	+ 8.6906	+ 8.6937	+278.9394	....	+ 6.2	+67.1	38.4
130 to 133	1.531	631.431	+ 8.7896	+ 8.7914	+ 8.7905	+287.7299	....	− 1.8	+65.3	3.2
133 to 134	0.676	632.107	+ 5.5492	+ 5.5466	+ 5.5479	+293.2778	....	+ 2.6	+67.9	6.8
134 to 135	0.706	632.813	+11.2106	+11.2098	+11.2102	+304.4880	....	+ 0.8	+68.7	0.6
135 to XX	0.139	632.952	+ 2.9403	+ 2.9416	+ 2.9409	+307.4289	24.9	− 1.3	+67.4	1.7
XX to 136	1.026	633.978	+22.2756	+22.2779	+22.2768	+329.7057	....	− 2.3	+65.1	5.3
136 to 137	0.243	634.221	+ 5.5416	+ 5.5443	+ 5.5429	+335.2486	....	− 2.7	+62.4	7.3
137 to 138	0.133	634.354	+ 2.8546	+ 2.8547	+ 2.8547	+338.1033	....	− 0.1	+62.3	0.0
138 to 139	0.891	635.245	+19.9130	+19.9181	+19.9155	+358.0188	....	− 5.1	+57.2	26.0
139 to 140	0.765	636.010	+17.2142	+17.2153	+17.2148	+375.2336	25.0	− 1.1	+56.1	1.2
140 to 141	0.879	636.889	+18.8744	+18.8775	+18.8759	+394.1095	....	− 3.1	+53.0	9.6
141 to 142	0.504	637.393	+10.9713	+10.9630	+10.9672	+405.0767	....	+ 8.3	+61.3	68.9
142 to 143	0.228	637.621	+ 5.4681	+ 5.4720	+ 5.4700	+410.5467	....	− 3.9	+57.4	15.2
143 to 144	0.774	638.395	+16.7073	+16.7043	+16.7058	+427.2525	....	+ 3.0	+60.4	9.0
144 to 145	0.792	639.187	+17.5417	+17.5463	+17.5440	+444.7965	....	− 4.6	+55.8	21.2
145 to 146	0.772	639.959	+17.2213	+17.2176	+17.2195	+462.0160	....	+ 3.7	+59.5	13.7
146 to 147	0.910	640.869	+20.1918	+20.1976	+20.1947	+482.2107	....	− 5.8	+53.7	33.6
147 to 148	0.634	641.503	+13.7728	+13.7715	+13.7721	+495.9828	....	+ 1.3	+55.0	1.7

Transcontinental line of Spirit-levels—Continued.

SECTION II.—FROM HAGERSTOWN, MD., TO GRAFTON, W. VA.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod A, first line.	Rod B, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ.	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	$(mm.)^2$
148 to 149	0.118	641.621	+ 2.8569	+ 2.8570	+ 2.8570	+498.8398	....	− 0.1	+54.9	0.0
149 to 150	0.103	641.724	+ 2.3830	+ 2.3828	+ 2.3829	+501.2227	....	+ 0.2	+55.1	0.0
150 to 151	0.812	642.536	+17.4878	+17.4924	+17.4901	+518.7128	....	− 4.6	+50.5	21.2
151 to 152	0.787	643.323	+17.1792	+17.1813	+17.1802	+535.8930	....	− 2.1	+48.4	4.4
152 to 153	0.898	644.221	+19.4817	+19.4816	+19.4816	+555.3746	....	+ 0.1	+48.5	0.0
153 to 154	0.884	645.105	+19.0520	+19.0573	+19.0547	+574.4293	....	− 5.3	+43.2	28.1
154 to 155	0.124	645.229	+ 2.3381	+ 2.3374	+ 2.3377	+576.7670	....	+ 0.7	+43.9	0.5
155 to 156	0.110	645.339	+ 2.8626	+ 2.8666	+ 2.8646	+579.6316	....	− 4.0	+39.9	16.0
156 to 158	1.136	646.475	+24.7405	+24.7387	+24.7396	+604.3712	....	+ 1.8	+41.7	3.2
158 to 159	1.234	647.709	+25.8738	+25.8784	+25.8761	+630.2473	....	− 4.6	+37.1	21.2
159 to 160	1.048	648.757	+23.1769	+23.1828	+23.1799	+653.4272	....	− 5.9	+31.2	34.8
160 to 161	0.138	648.895	+ 3.0246	+ 3.0234	+ 3.0240	+656.4512	....	+ 1.2	+32.4	1.4
161 to 176	0.932	649.827	+20.5837	+20.5867	+20.5852	+677.0364	....	− 3.0	+29.4	9.0
176 to XXV	0.773	650.600	+16.3311	+16.3247	+16.3279	+693.3643	25.7	+ 6.4	+35.8	41.0
XXV to 177	0.434	651.034	+ 4.5086	+ 4.5052	+ 4.5069	+697.8712	....	+ 3.4	+39.2	11.6
177 to 178	1.074	652.108	+16.4486	+16.4541	+16.4513	+714.3225	....	− 5.5	+33.7	30.2
178 to 179	0.996	653.104	+17.1726	+17.1690	+17.1708	+731.4933	....	+ 3.6	+37.3	13.0
179 to 180	0.702	653.806	+14.1850	+14.1880	+14.1865	+745.6798	....	− 3.0	+34.3	9.0
180 to 181	0.842	654.648	+16.6639	+16.6678	+16.6659	+762.3457	....	− 3.9	+30.4	15.2
181 to 182	0.998	655.646	+17.4292	+17.4252	+17.4272	+779.7729	....	+ 4.0	+34.1	16.0
182 to 183	1.353	656.999	+20.7280	+20.7305	+20.7292	+800.5021	....	− 2.5	+31.9	6.3
183 to 184	1.254	658.253	−12.7362	−12.7351	−12.7357	+787.7664	....	− 1.1	+30.8	1.2
184 to 185	1.468	659.721	−14.6186	−14.6117	−14.6152	+773.1512	....	− 6.9	+23.9	47.6
185 to 186	0.235	659.956	− 2.5130	− 2.5145	− 2.5137	+770.6375	....	+ 1.5	+25.4	2.2
186 to 171	1.735	661.691	−17.0557	−17.0563	−17.0560	+753.5815	....	+ 0.6	+26.0	0.4
171 to XXIII	0.528	662.219	− 4.9314	− 4.9300	− 4.9307	+748.6508	26.1	− 1.4	+24.6	2.0
XXIII to 170	1.302	663.521	− 7.1585	− 7.1658	− 7.1622	+741.4886	....	+ 7.3	+31.9	53.3
170 to 169	1.781	665.302	− 5.1545	− 5.1546	− 5.1545	+736.3341	....	+ 0.1	+32.0	0.0
169 to XXII	1.566	666.868	− 3.4189	− 3.4127	− 3.4158	+732.9183	26.3	− 6.2	+25.8	38.4
XXII to 168	1.618	668.486	− 4.4137	− 4.4204	− 4.4170	+728.5013	....	+ 6.7	+32.5	44.9
168 to 167	1.662	670.148	− 2.8081	− 2.8234	− 2.8158	+725.6855	....	+15.3	+47.8	234.1
167 to 162	1.563	671.711	− 1.2918	− 1.2934	− 1.2926	+724.3929	....	+ 1.6	+49.4	2.6
162 to XXI	1.724	673.435	+ 0.6201	+ 0.6215	+ 0.6208	+725.0137	....	− 1.4	+48.0	2.0
XXI to K	0.475	673.910	− 0.8695	− 0.8649	− 0.8672	+724.1465	26.9	− 4.6	+43.4	21.2
K to 163	1.406	675.316	+10.6557	+10.6503	+10.6530	+734.7995	....	+ 5.4	+48.8	29.2
163 to 164	1.596	676.912	+10.4175	+10.4090	+10.4132	+745.2127	....	+ 8.5	+57.3	72.2
164 to 165	0.248	677.160	+ 0.2986	+ 0.2980	+ 0.2983	+745.5110	....	+ 0.6	+57.9	0.4
165 to 166	0.306	677.466	− 0.2969	− 0.2978	− 0.2973	+745.2137	....	+ 0.9	+58.8	0.8
166 to 172	1.176	678.642	+ 7.0076	+ 7.0115	+ 7.0095	+752.2232	....	− 3.9	+54.9	15.2
172 to 173	1.418	680.060	+ 2.9448	+ 2.9467	+ 2.9458	+755.1690	....	− 1.9	+53.0	3.6
173 to 174	1.744	681.804	−12.7354	−12.7339	−12.7347	+742.4343	....	− 1.5	+51.5	2.2
174 to 175	0.260	682.064	− 0.2658	− 0.2656	− 0.2657	+742.1686	....	− 0.2	+51.3	0.0
175 to XXIV	0.270	682.334	− 0.0822	− 0.0816	− 0.0819	+742.0867	27.2	− 0.6	+50.7	0.4
XXIV to 187	1.454	683.788	+11.1691	+11.1639	+11.1665	+753.2532	....	+ 5.2	+55.9	27.0
187 to XXVI	0.906	684.694	+ 3.0095	+ 3.0029	+ 3.0062	+756.2594	27.3	+ 6.6	+62.5	43.6
XXVI to 188	0.796	685.490	+ 7.6488	+ 7.6509	+ 7.6499	+763.9093	....	− 2.1	+60.4	4.4
188 to 189	1.167	686.657	+ 6.3244	+ 6.3257	+ 6.3251	+770.2314	....	− 1.3	+59.1	1.7
189 to 190	0.297	686.954	+ 1.3364	+ 1.3336	+ 1.3350	+771.5694	....	+ 2.8	+61.9	7.8
190 to 191	2.082	689.036	− 0.8092	− 0.8068	− 0.8080	+770.7614	....	− 2.4	+59.5	5.8
191 to XXVII	1.000	690.036	−23.1014	−23.0998	−23.1006	+747.6608	27.4	− 1.6	+57.9	2.6
XXVII to 192	1.034	691.070	−22.0227	−22.0170	−22.0199	+725.6409	....	− 5.7	+52.2	32.5
192 to 193	0.849	691.919	−18.9775	−18.9674	−18.9724	+706.6685	....	−10.1	+42.1	102.0
193 to 194	0.370	692.289	− 7.8838	− 7.8839	− 7.8839	+698.7846	....	+ 0.1	+42.2	0.0
194 to 195	0.897	693.186	−19.7166	−19.7217	−19.7191	+679.0655	....	+ 5.1	+47.3	26.0
195 to 196	0.888	694.074	−19.4975	−19.4960	−19.4968	+659.5687	....	− 1.5	+45.8	2.2
196 to 197	0.481	694.555	−10.9016	−10.9052	−10.9034	+648.6653	....	+ 3.6	+49.4	13.0
197 to 198	0.560	695.115	−10.3929	−10.3944	−10.3936	+638.2717	....	+ 1.5	+50.9	2.

Transcontinental line of Spirit-levels—**Continued.**

SECTION II.—FROM HAGERSTOWN, MD., TO GRAFTON, W. VA.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks.			Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy.		Δ^2
			Rod A, first line.	Rod B, second line.	Mean.			Partial Δ	Total.	
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	$(mm)^2$
198 to 199	0.920	696.035	−17.2855	−17.2810	−17.2833	+620.9884	....	− 4.5	+46.4	20.2
199 to 200	0.880	696.915	−19.0624	−19.0571	−19.0597	+601.9287	....	− 5.3	+41.1	28.1
200 to 201	0.785	697.700	−16.6539	−16.6531	−16.6535	+585.2752	....	− 0.8	+40.3	0.6
201 to 202	0.484	698.184	−11.1995	−11.1997	−11.1996	+574.0756	....	+ 0.2	+40.5	0.0
202 to 203	0.121	698.305	− 2.3662	− 2.3677	− 2.3670	+571.7086	....	+ 1.5	+42.0	2.2
203 to 204	0.116	698.421	− 2.6793	− 2.6791	− 2.6792	+569.0294	....	− 0.2	+41.8	0.0
204 to 205	0.765	699.186	−16.2671	−16.2654	−16.2662	+552.7632	....	− 1.7	+40.1	2.9
205 to 206	0.872	700.058	−18.7509	−18.7440	−18.7475	+534.0157	....	− 6.9	+33.2	47.6
206 to 207	0.896	700.954	−19.1809	−19.1774	−19.1791	+514.8366	....	− 3.5	+29.7	12.2
207 to L	0.880	701.834	−19.8225	−19.8213	−19.8219	+495.0147	28.0	− 1.2	+28.5	1.4
L to 208	0.625	702.459	−13.6424	−13.6417	−13.6421	+481.3726	....	− 0.7	+27.8	0.5
208 to 209	0.924	703.383	−16.3822	−16.3794	−16.3808	+464.9918	....	− 2.8	+25.0	7.8
209 to 210	1.412	704.795	−14.2263	−14.2155	−14.2209	+450.7709	....	−10.8	+14.2	116.6
210 to 211	1.669	706.464	−17.5770	−17.5764	−17.5767	+433.1942	....	− 0.6	+13.6	0.4
211 to XXVIII	1.268	707.732	− 6.2425	− 6.2424	− 6.2424	+426.9518	28.2	− 0.1	+13.5	0.0
XXVIII to 212	0.887	708.619	+10.9820	+10.9815	+10.9817	+437.9335	....	+ 0.5	+14.0	0.2
212 to 213	0.856	709.475	+16.6329	+16.6306	+16.6318	+454.5653	....	+ 2.3	+16.3	5.3
213 to 214	1.124	710.599	+23.4658	+23.4704	+23.4681	+478.0334	....	− 4.6	+11.7	21.2
214 to 215	0.702	711.301	+13.7024	+13.7056	+13.7040	+491.7374	....	− 3.2	+ 8.5	10.2
215 to 216	1.118	712.419	+23.1035	+23.1060	+23.1047	+514.8421	....	− 2.5	+ 6.0	6.3
216 to XXIX	0.464	712.883	+ 8.6224	+ 8.6254	+ 8.6239	+523.4660	28.4	− 3.0	+ 3.0	9.0
XXIX to 217	0.813	713.696	+16.8893	+16.8865	+16.8879	+540.3539	....	+ 2.8	+ 5.8	7.8
217 to 218	0.872	714.568	+17.3817	+17.3807	+17.3812	+557.7351	....	+ 1.0	+ 6.8	1.0
218 to 219	1.262	715.830	+ 3.8555	+ 3.8533	+ 3.8544	+561.5895	....	+ 2.0	+ 8.8	4.0
219 to 220	2.362	718.192	− 4.8390	− 4.8467	− 4.8429	+556.7466	....	+ 7.7	+16.5	59.3
220 to 221	1.700	719.892	−13.2774	−13.2683	−13.2728	+543.4738	....	− 9.1	+ 7.4	82.8
221 to 222	1.242	721.134	−25.1201	−25.1256	−25.1229	+518.3509	....	+ 5.5	+12.9	30.2
222 to 223	1.218	722.352	−25.3955	−25.3917	−25.3936	+492.9573	....	− 3.8	+ 9.1	14.4
223 to 224	1.014	723.366	−19.6401	−19.6434	−19.6418	+473.3155	....	+ 3.3	+12.4	10.9
224 to 225	1.125	724.491	−22.8407	−22.8468	−22.8437	+450.4718	....	+ 6.1	+18.5	37.2
225 to 226	1.279	725.770	−25.9283	−25.9302	−25.9293	+424.5425	....	+ 1.9	+20.4	3.6
226 to 227	0.878	726.648	−16.7356	−16.7363	−16.7359	+407.8066	....	+ 0.7	+21.1	0.5
227 to 228	1.419	728.067	−28.3652	−28.3767	−28.3710	+379.4356	....	+11.5	+32.6	132.2
228 to 229	1.586	729.653	−12.8009	−12.8059	−12.8034	+366.6322	....	+ 5.0	+37.6	25.0
229 to 230	1.451	731.104	−13.5412	−13.5537	−13.5475	+353.0847	....	+12.5	+50.1	156.2
230 to 231	1.625	732.729	−10.9522	−10.9568	−10.9545	+342.1302	....	+ 4.6	+54.7	21.2
231 to 232	1.644	734.373	− 6.7658	− 6.7656	− 6.7657	+335.3645	....	− 0.2	+54.5	0.0
232 to 233	0.595	734.968	− 1.9741	− 1.9741	− 1.9741	+333.3904	....	0.0	+54.5	0.0
233 to 234	0.305	735.273	− 1.8678	− 1.8606	− 1.8642	+331.5262	....	− 7.2	+47.3	51.8
234 to 235	0.296	735.569	− 0.8823	− 0.8814	− 0.8818	+330.6444	....	− 0.9	+46.4	0.8
235 to 236	1.947	737.516	− 6.6076	− 6.6133	− 6.6105	+324.0339	....	+ 5.7	+52.1	32.5
236 to 237	1.844	739.360	− 3.4272	− 3.4254	− 3.4263	+320.6076	....	− 1.8	+50.3	3.2
237 to 238	0.617	739.977	− 1.8823	− 1.8821	− 1.8822	+318.7254	....	− 0.2	+50.1	0.0
238 to 239	1.185	741.162	− 2.0114	− 2.0099	− 2.0106	+316.7148	....	− 1.5	+48.6	2.2
239 to 240	0.842	742.004	+ 0.2588	+ 0.2571	+ 0.2579	+316.9727	....	+ 1.7	+50.3	2.9
240 to 241	0.869	742.873	− 1.0637	− 1.0672	− 1.0654	+315.9073	....	+ 3.5	+53.8	12.2
241 to 242	2.122	744.995	− 2.8666	− 2.8748	− 2.8707	+313.0366	....	+ 8.2	+62.0	67.2
242 to XXX	1.392	746.387	− 0.8952	− 0.8958	− 0.8955	+312.1411	29.8	+ 0.6	+62.6	0.4
XXX to 243	1.879	748.266	− 8.4117	− 8.4180	− 8.4149	+303.7262	....	+ 6.3	+68.9	39.7
243 to M	1.610	749.876	+ 0.1371	+ 0.1389	+ 0.1380	+303.8642	29.9	− 1.8	+67.1	3.2

SECTION II.—*Description of primary and secondary bench-marks between Hagerstown, Md., and Grafton, W. Va.*

A—Hagerstown, Md. Already described.

Nos. I, II, IV, and V—Cut on top of mile-posts 1, 2, 4, and 5 on the turnpike between Hagerstown and Williamsport. These probably cannot be depended upon as permanent.

B—The bottom surface of a square cavity, cut on the top surface of the stone on the west side of the aqueduct of Chesapeake and Ohio Canal over the Conococheague River at Williamsport, Md. It is marked thus:

B
B □ M
U. S. C. S.
Nov. 1877

C—About 7 miles west of Williamsport, Md. Cut on the coping-stone of Dam No. 5, Potomac River. It is marked thus:

C
B □ M
U. S. C. S.
1877

No. VI—About 7¾ miles west of Williamsport, Md. Cut on top layer of stone of the second canal-lock (Chesapeake and Ohio Canal), above Dam No. 5.

D—Nine and one-fourth miles west of Williamsport, Md. Cut on the top layer of stone at west end of the sixth lock above Dam No. 5.

No. VII—Cut on the coping-stone ot the upper end of "overflow" at "Big Pool," Chesapeake and Ohio Canal. It is about 13½ miles west of Williamsport, Md., and nearly opposite Cherry Run Station of Baltimore and Ohio Railroad.

E—Cut on the coping-stone of the aqueduct (Chesapeake and Ohio Canal) over Licking Creek, about 8 miles east of Hancock, Md. It is marked thus:

E
B □ M
U. S. C. S.
1877.

No. VIII—Cut on the coping-stone at the southeast end of Lock No. 52, Chesapeake and Ohio Canal, and is about 1 mile east of Hancock, Md.

F—Cut on the coping-stone on the middle of the north side of the Chesapeake and Ohio Canal aqueduct at Hancock, Md. It is marked thus:

F
B □ M
U. S. C. S.
1878.

No. IX—Cut on the coping-stone of Lock No. 53, Chesapeake and Ohio Canal, and is about 6 miles west of Hancock, Md.

G—Cut on the coping-stone of Lock No. 55, Chesapeake and Ohio Canal, at Dam No. 6, and about 10 miles west of Hancock, Md. It is marked thus:

G
B □ M
U. S. C. S.
1878.

No. X—Cut on the coping-stone at the north end of Lock No. 56, Chesapeake and Ohio Canal, about 12½ miles west of Hancock, Md.

No. XI—Cut on the top of the wing-wall at the south side and east end of Lock No. 57, Chesapeake and Ohio Canal. It is about 15¼ miles west of Hancock and 4¾ miles east of Little Orleans, Md.

No. XII—Little Orleuas, Md. Cut on the coping-stone of the aqueduct (Chesapeake and Ohio Canal) over Fifteen-mile Creek.

No. XIII—About 3 miles west of Little Orleans, Md. Cut on the coping of Lock No. 58, Chesapeake and Ohio Canal.

H—About 12 miles west of Little Orleans, Md., and 2 miles east of the canal tunnel. It is cut on the coping of Lock No. 61, and is marked thus:

H
B □ M
U. S. C. S.
1878

No. XIV—At the north end of the canal tunnel. It is cut on the stone foundation, a short distance below the level of the tow-path.

No. XV—Cut on the coping-stone of Lock No. 67, Chesapeake and Ohio Canal, and is about 5 miles east of Oldtown, Md.

No. XVI—Cut on the coping-stone of Lock No. 72, Chesapeake and Ohio Canal, and is about 9¼ miles east of Cumberland, Md.

I—Cumberland, Md. Cut on the coping stone of the feed-lock, at the western terminus of the Chesapeake and Ohio Canal. It is marked thus:

I
B □ M
U. S. C. S.
1878

No. XVII—Cut on the abutment of a small drain on the Baltimore and Ohio Railroad, about 5½ miles west of Cumberland, Md. It is marked thus: B □ M.

No. XVIII—Cut on the foundation-stone, at the southwest angle of a drain on the Baltimore and Ohio Railroad, about 12 miles west of Cumberland, Md. It is marked thus: B □ M.

J—Cut on the top of the middle pier of Baltimore and Ohio Railroad bridge, over a small drain about one-fourth of a mile east of Keyser, W. Va. It is marked thus:

J
B □ M
U. S. C. S.
1878.

No. XX—Cut on the top step at the northwest corner of the Baltimore and Ohio Railroad bridge over the Potomac River at Bloomington, Garrett County, Maryland. It is also about 2 miles west of Piedmont, W. Va., and is marked thus: B □ M.

No. XXI—About 1 mile west of Oakland, Md. Cut on a large rock beside the track of the Baltimore and Ohio Railroad.

No. XXII—About 3 miles east of Oakland, Md. Cut on the west abutment of a small bridge, Baltimore and Ohio Railroad, and is marked thus: B □ M.

No. XXIII—Cut on top stone of a "cattle guard," a short distance north of Deer Park, Garrett County, Maryland. It is marked thus: B □ M.

No. XXIV—Near Hutton's Switch Station, Md. (Baltimore and Ohio Railroad). Cut on the abutment of a bridge over a small run.

No. XXV—Cut on the abutment of a small bridge (Baltimore and Ohio Railroad) about 10¾ miles west of Bloomington, Md. It is marked B □ M.

K—Cut on the abutment, southwest corner of Baltimore and Ohio Railroad bridge over the Youghiogheny River. It is about 1¼ miles west of Oakland, Md., and is marked thus:

K
B □ M
U. S. C. S.
1878

No. XXVI—Two miles east of Cranberry Summit Station of Baltimore and Ohio Railroad, Preston County, West Virginia. Cut on southeast corner of railroad bridge over a small stream.

No. XXVII—Cut on the coping-stone, near the middle of the "slide-wall" (Baltimore and Ohio Railroad), about 1½ miles west of Cranberry Summit, and is marked thus: B □ M.

L—Cut on the coping-stone of abutment at northwest corner of the Baltimore and Ohio Railroad bridge over Salt Lick Creek, 4 miles east of Rowlesburg, W. Va. It is marked thus:

L
B □ M
U. S. C. S.
1878

No. XXVIII—Rowlesburg, W. Va. Cut at the base of the centre pillar at the west end of Baltimore and Ohio Railroad bridge over Cheat River. It is marked thus: B □ M.

No. XXIX—Cut on top of the "Buckhorn Wall," about 40 metres from its eastern end. It is about 3¼ miles west of Rowlesburg, W. Va., and is marked thus: B □ M.

No. XXX—Cut on corner-stone of abutment of a small bridge, Baltimore and Ohio Railroad, about 2 miles east of Grafton, W. Va.

Transcontinental line of Spirit-levels—Continued.

SECTION III.—FROM GRAFTON, W. VA., TO ATHENS, OHIO.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks.			Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy.		Δ^2
			Rod A, first line.	Rod B, second line.	Mean.			Partial Δ	Total.	
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	$(mm)^2$
M	....	749.876	....	....	....	+303.8642	29.9	....	+ 67.1	....
M to 244	1.582	751.458	+ 0.6017	+ 0.6021	+ 0.6019	+304.4661	....	− 0.4	+ 66.7	0.2
244 to 245	1.592	753.050	+ 0.5691	+ 0.5660	+ 0.5676	+305.0337	....	+ 3.1	+ 69.8	9.6
245 to 246	1.004	754.054	+ 2.5745	+ 2.5815	+ 2.5780	+307.6117	....	− 7.0	+ 62.8	49.0
246 to 247	0.566	754.620	+ 0.3852	+ 0.3836	+ 0.3844	+307.9961	....	+ 1.6	+ 64.4	2.6
247 to 248	0.237	754.857	+ 0.1918	+ 0.1930	+ 0.1924	+308.1885	....	− 1.2	+ 63.2	1.4
248 to 249	1.901	756.758	+ 5.1765	+ 5.1757	+ 5.1761	+313.3646	....	+ 0.8	+ 64.0	0.6
249 to XXXI	1.699	758.457	+16.6513	+16.6410	+16.6461	+330.0107	30.2	+10.3	+ 74.3	106.1
XXXI to 250	1.722	760.179	+17.6430	+17.6348	+17.6389	+347.6496	....	+ 8.2	+ 82.5	67.2
250 to 251	0.696	760.875	− 2.4806	− 2.4899	− 2.4852	+345.1644	....	+ 9.3	+ 91.8	86.5
251 to 252	0.202	761.077	− 2.3132	− 2.3025	− 2.3079	+342.8565	....	−10.7	+ 81.1	114.5
252 to 253	1.574	762.651	−15.5557	−15.5574	−15.5565	+327.3000	....	+ 1.7	+ 82.8	2.9
253 to 254	1.068	763.719	−10.4566	−10.4612	−10.4589	+316.8411	....	+ 4.6	+ 87.4	21.2
254 to 255	1.392	765.111	− 2.8579	− 2.8662	− 2.8621	+313.9790	....	+ 8.3	+ 95.7	68.9
255 to 256	0.520	765.631	− 1.2810	− 1.2852	− 1.2831	+312.6959	....	+ 4.2	+ 99.9	17.6
256 to 257	0.521	766.152	+ 2.1326	+ 2.1284	+ 2.1305	+314.8264	....	+ 4.2	+104.1	17.6
257 to 258	1.668	767.820	− 7.4740	− 7.4682	− 7.4711	+307.3553	....	− 5.8	+ 98.3	33.6
258 to 259	1.693	769.513	− 1.9129	− 1.9045	− 1.9087	+305.4466	....	− 8.4	+ 89.9	70.6
259 to 260	1.858	771.371	+ 0.4836	+ 0.4807	+ 0.4822	+305.9288	....	+ 2.9	+ 92.8	8.4
260 to 261	1.886	773.257	− 0.1704	− 0.1749	− 0.1727	+305.7561	....	+ 4.5	+ 97.3	20.2
261 to 262	0.995	774.252	+ 3.1431	+ 3.1437	+ 3.1434	+308.8995	....	− 0.6	+ 96.7	0.4
262 to 263	1.600	775.852	−10.1136	−10.1137	−10.1136	+298.7859	....	+ 0.1	+ 96.8	0.0
263 to XXXII	1.567	777.419	− 0.1590	− 0.1564	− 0.1577	+298.6282	31.2	− 2.6	+ 94.2	6.8
XXXII to 264	1.587	779.006	+10.0635	+10.0514	+10.0575	+308.6857	....	+12.1	+106.3	146.4
264 to 265	0.932	779.938	+ 8.9285	+ 8.9306	+ 8.9295	+317.6152	....	− 2.1	+104.2	4.4
265 to 266	0.982	780.920	+10.1117	+10.1186	+10.1151	+327.7303	....	− 6.9	+ 97.3	47.6
266 to 267	1.112	782.032	+ 5.6101	+ 5.6212	+ 5.6157	+333.3460	....	−11.1	+ 86.2	123.2
267 to 268	1.785	783.817	−16.4038 A and B	−16.4180 −16.3987	−16.4068	+316.9392	....	+14.2	+100.4	201.6
268 to 269	0.823	784.640	− 2.0214	− 2.0180	− 2.0197	+314.9195	....	− 3.4	+ 97.0	11.6
269 to 270	1.982	786.622	−11.9896	−11.9995	−11.9945	+302.9250	....	+ 9.9	+106.9	98.0
270 to 271	2.161	788.783	−11.4046	−11.3985	−11.4016	+291.5234	....	− 6.1	+100.8	37.2
271 to 274	1.180	789.963	+ 4.7982	+ 4.7868	+ 4.7925	+296.3159	....	+11.4	+112.2	130.0
274 to 273	2.204	792.167	+ 4.7504	+ 4.7484	+ 4.7494	+301.0653	....	+ 2.0	+114.2	4.0
273 to 272	1.496	793.663	+ 7.4260	+ 7.4173	+ 7.4216	+308.4869	....	+ 8.7	+122.9	75.7
272 to 275	1.501	795.164	+15.0037	+15.0012	+15.0025	+323.4894	....	+ 2.5	+125.4	6.2
275 to 276	2.618	797.782	+22.0995	+22.0911	+22.0953	+345.5847	....	+ 8.4	+133.8	70.6
276 to 277	0.993	798.775	− 9.8501	− 9.8508	− 9.8505	+335.7342	....	+ 0.7	+134.5	0.5
277 to 278	1.562	800.337	−15.6472	−15.6410	−15.6441	+320.0901	....	− 6.2	+128.3	38.4
278 to 279	1.004	801.341	− 0.7555	− 0.7617	− 0.7586	+319.3315	....	+ 6.2	+134.5	38.4

Transcontinental line of Spirit-levels—Continued.

SECTION III.—FROM GRAFTON, W. VA., TO ATHENS, OHIO—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks.			Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy.		Δ^2
			Rod A, first line.	Rod B, second line.	Mean.			Partial Δ	Total.	
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	(*mm*)²
279 to 280	0.732	802.073	+ 6.3633	+ 6.3567	+ 6.3600	+325.6915	....	+ 6.6	+141.1	42.6
280 to 281	1.873	803.946	−13.1677	−13.1589	−13.1633	+312.5282	....	− 8.8	+132.3	77.4
281 to 282	1.754	805.700	+ 2.6249	+ 2.6252	+ 2.6251	+315.1533	....	− 0.3	+132.0	0.0
282 to 283	1.006	806.706	+ 1.8837	+ 1.8787	+ 1.8812	+317.0345	....	+ 5.0	+137.0	25.0
283 to 284	2.010	808.716	+ 6.4061	+ 6.4161	+ 6.4111	+323.4456	....	−10.0	+127.0	100.0
284 to 285	1.916	810.632	− 7.1256	− 7.1202	− 7.1229	+316.3227	....	− 5.4	+121.6	29.2
285 to 286	1.513	812.145	−15.2583	−15.2626	−15.2605	+301.0622	....	+ 4.3	+125.9	18.5
286 to 287	1.482	813.627	−14.7049	−14.7004	−14.7026	+286.3596	....	− 4.5	+121.4	20.2
287 to 288	1.728	815.355	−16.7947	−16.7967	−16.7957	+269.5639	....	+ 2.0	+123.4	4.0
288 to 289	2.306	817.661	−10.4547	−10.4515	−10.4531	+259.1108	....	− 3.2	+120.2	10.2
289 to 290	0.334	817.995	− 0.6052	− 0.6080	− 0.6066	+258.5042	....	+ 2.8	+123.0	7.8
290 to 291	1.856	819.851	−10.1455	−10.1406	−10.1431	+248.3611	....	− 4.9	+118.1	24.0
291 to 292	1.819	821.670	+ 0.2335	+ 0.2359	+ 0.2347	+248.5958	....	− 2.4	+115.7	5.8
292 to 293	2.426	824.096	− 3.8822	− 3.8955	− 3.8888	+244.7070	....	+13.3	+129.0	176.9
293 to XXXIII	2.096	826.192	− 0.7488	− 0.7443	− 0.7466	+243.9604	34.0	− 4.5	+124.5	20.2
XXXIII to 294	1.502	827.694	− 4.3221	− 4.3198	− 4.3209	+239.6395	....	− 2.3	+122.2	5.3
294 to N	1.948	829.642	+ 5.7485	+ 5.7469	+ 5.7477	+245.3872	34.0	+ 1.6	+123.8	2.6
N to 295	1.666	831.308	+14.9851	+14.9801	+14.9826	+260.3698	....	+ 5.0	+128.8	25.0
295 to 296	2.105	833.413	− 1.2417	− 1.2410	− 1.2414	+259.1284	....	− 0.7	+128.1	0.5
296 to 297	1.238	834.651	−10.6765	−10.6727	−10.6746	+248.4538	....	− 3.8	+124.3	14.4
297 to 298	2.333	836.984	+15.8253	+15.8310	+15.8282	+264.2820	....	− 5.7	+118.6	32.5
298 to 299	1.332	838.316	+13.5795	+13.5767	+13.5781	+277.8601	....	+ 2.8	+121.4	7.8
299 to 300	2.134	840.450	+ 2.1549	+ 2.1594	+ 2.1571	+280.0172	....	− 4.5	+116.9	20.2
300 to 301	1.606	842.056	−15.9740	−15.9759	−15.9749	+264.0423	....	+ 1.9	+118.8	3.6
301 to 302	1.373	843.429	−13.7521	−13.7452	−13.7487	+250.2936	....	− 6.9	+111.9	47.6
302 to XXXIV	1.838	845.267	− 5.5182	− 5.5239	− 5.5210	+244.7726	34.3	+ 5.7	+117.6	32.5
XXXIV to 303	0.541	845.808	+ 5.3126	+ 5.3100	+ 5.3113	+250.0839	....	+ 2.6	+120.2	6.8
303 to 304	1.920	847.728	+18.9970	+19.0022	+18.9996	+269.0835	....	− 5.2	+115.0	27.0
304 to 305	1.626	849.354	− 1.1946	− 1.1908	− 1.1927	+267.8908	....	− 3.8	+111.2	14.4
305 to 306	2.272	851.626	− 4.4404 A and B	− 4.4220 − 4.4379	− 4.4334	+263.4574	....	−12.2	+ 99.0	148.8
306 to 307	1.667	853.293	+ 8.6697	+ 8.6719	+ 8.6708	+272.1282	....	− 2.2	+ 96.8	4.8
307 to 308	1.867	855.160	−18.3885	−18.3940	−18.3913	+253.7369	....	+ 5.5	+102.3	30.2
308 to 309	2.414	857.574	−12.6726	−12.6695	−12.6711	+241.0658	....	− 3.1	+ 99.2	9.6
309 to 310	1.338	858.912	− 2.5662	− 2.5605	− 2.5633	+238.5025	....	− 5.7	+ 93.5	32.5
310 to 311	2.115	861.027	− 7.0902	− 7.0892	− 7.0897	+231.4128	....	− 1.0	+ 92.5	1.0
311 to 312	1.308	862.335	− 6.1530	− 6.1541	− 6.1536	+225.2592	....	+ 1.1	+ 93.6	1.2
312 to 313	1.997	864.332	−11.4254	−11.4221	−11.4237	+213.8355	....	− 3.3	+ 90.3	10.9
313 to 314	0.496	864.828	+ 2.1633	+ 2.1579	+ 2.1606	+215.9961	....	+ 5.4	+ 95.7	29.2
314 to 315	0.866	865.694	− 4.2949	− 4.2945	− 4.2947	+211.7014	....	− 0.4	+ 95.3	0.2
315 to XXXV	0.160	865.854	− 0.1252	− 0.1266	− 0.1259	+211.5755	34.9	+ 1.4	+ 96.7	2.0
XXXV to 316	1.886	867.740	− 2.5895	− 2.5872	− 2.5883	+208.9872	....	− 2.3	+ 94.4	5.3
316 to XXXVI	1.605	869.345	+ 0.1770	+ 0.1797	+ 0.1783	+209.1655	34.9	− 2.7	+ 91.7	7.3
XXXVI to 317	1.412	870.757	− 3.0278	− 3.0272	− 3.0275	+206.1380	....	− 0.6	+ 91.1	0.4
317 to 325	0.602	871.359	+ 5.4569	+ 5.4558	+ 5.4564	+211.5944	....	+ 1.1	+ 92.2	1.2
325 to 324	1.622	872.981	+15.8654	+15.8709	+15.8681	+227.4625	....	− 5.5	+ 86.7	30.2
324 to 323	1.846	874.827	+18.6473	+18.6424	+18.6449	+246.1074	....	+ 4.9	+ 91.6	24.0
323 to 322	1.133	875.960	+10.5281	+10.5251	+10.5266	+256.6340	....	+ 3.0	+ 94.6	9.0
322 to 320	1.464	877.424	−14.1583	−14.1585	−14.1584	+242.4756	....	+ 0.2	+ 94.8	0.0
320 to 319	0.457	877.881	− 4.1323	− 4.1318	− 4.1321	+238.3435	....	− 0.5	+ 94.3	0.2
319 to 318	2.370	880.251	−22.9786	−22.9823	−22.9804	+215.3631	....	+ 3.7	+ 98.0	13.7
318 to XXXVII	1.688	881.939	− 2.8448	− 2.8434	− 2.8441	+212.5190	35.0	− 1.4	+ 96.6	2.0
XXXVII to XXXVIII	1.736	883.675	− 1.1464	− 1.1452	− 1.1458	+211.3732	35.0	− 1.2	+ 95.4	1.4
XXXVIII to 321	2.176	885.851	+13.3652	+13.3728	+13.3690	+224.7422	....	− 7.6	+ 87.8	57.8
321 to 326	1.695	887.546	+14.3394 A and B	+14.3597 +14.3445	+14.3479	+239.0901	....	−13.5	+ 74.3	182.2
326 to 327	0.655	888.201	− 5.4051	− 5.4010	− 5.4031	+233.6870	....	− 4.1	+ 70.2	16.8
327 to 328	1.299	889.500	−13.1363 −13.1452	−13.1499 −13.1425	−13.1435	+220.5435	....	+ 5.4	+ 75.6	29.2

Transcontinental line of Spirit-levels—Continued.

SECTION III.—FROM GRAFTON, W. VA., TO ATHENS, OHIO—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod A, first line.	Rod B, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ²
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	(*mm.*)²
328 to 329	1.013	890.513	− 9.5916	− 9.5949	− 9.5932	+210.9503	......	+ 3.3	+ 78.9	10.9
329 to 330	1.447	891.960	−13.5856	−13.5916	−13.5886	+197.3617	....	− 3.0	+ 75.9	9.0
330 to 331	2.447	894.407	− 4.9181	− 4.9131	− 4.9156	+192.4461	....	− 5.0	+ 70.9	25.0
331 to 332	1.302	895.709	− 1.2374	− 1.2275	− 1.2325	+191.2136	....	− 9.9	+ 61.0	98.0
332 to 333	1.923	897.632	− 5.5999	− 5.6036	− 5.6017	+185.6119	....	+ 3.7	+ 64.7	13.7
333 to 334	1.848	899.480	+ 0.0093	+ 0.0129	+ 0.0111	+185.6230	... .	− 3.6	+ 61.1	13.0
334 to 335	1.778	901.258	− 0.5651	− 0.5659	− 0.5655	+185.0575	....	+ 0.8	+ 61.9	0.6
335 to 336	1.222	902.480	+ 0.8127	+ 0.8093	+ 0.8110	+185.8685	....	+ 3.4	+ 65.3	11.6
336 to 337	2.052	904.532	− 0.0890	− 0.0798	− 0.0844	+185.7841	....	− 9.2	+ 56.1	84.6
337 to 338	2.415	906.947	− 0.3896	− 0.3939	− 0.3917	+185.3924	....	+ 4.3	+ 60.4	18.5
338 to 339	2.210	909.157	+ 2.4611	+ 2.4662	+ 2.4636	+187.8560	....	− 5.1	+ 55.3	26.0
339 to 340	1.121	910.278	+ 6.1105	+ 6.1138	+ 6.1122	+193.9682	....	− 3.3	+ 52.0	10.9
340 to 341	2.231	912.509	− 8.3213	− 8.3265	− 8.3239	+185.6443	....	+ 5.2	+ 57.2	27.0
341 to 342	1.953	914.462	+ 0.0448	+ 0.0380	+ 0.0414	+185.6857	....	+ 6.8	+ 64.0	46.2
342 to XXXIX	0.789	915.251	− 0.4247	− 0.4193	− 0.4220	+185.2637	36.1	− 5.4	+ 58.6	29.2
XXXIX to 343	2.194	917.445	+ 9.5731	+ 9.5744	+ 9.5737	+194.8374	....	− 1.3	+ 57.3	1.7
343 to 344	0.362	917.807	− 7.0733	− 7.0705	− 7.0719	+187.7655	....	− 2.8	+ 54.5	7.8
344 to O	0.166	917.973	+ 0.0451	+ 0.0452	+ 0.0452	+187.8107	36.2	− 0.1	+ 54.4	0.0
O to 345	0.725	918.698	− 6.9335	− 6.9356	− 6.9346	+180.8761	....	+ 2.1	+ 56.5	4.4
345 to 346	0.254	918.952	− 0.5732	− 0.5790	− 0.5761	+180.3000	....	+ 5.8	+ 62.3	33.6
346 to XL	0.439	919.391	+ 9.1618	+ 9.1619	+ 9.1619	+189.4619	36.2	− 0.1	+ 62.2	0.0
XL to 347	0.821	920.212	+ 3.5356	+ 3.5290	+ 3.5323	+192.9942	....	+ 6.6	+ 68.8	43.6
347 to 348	2.518	922.730	+ 5.3259	+ 5.3177	+ 5.3218	+198.3160	....	+ 8.2	+ 77.0	67.2
348 to 349	2.412	925.142	− 3.6913 A and B	− 3.7097 − 3.7098	− 3.7036	+194.6124	....	+12.3	+ 89.3	151.3
349 to 350	0.292	925.434	− 1.4239 A and B	− 1.4277 − 1.4225	− 1.4247	+193.1877	....	+ 2.5	+ 91.8	6.2
350 to 351	2.093	927.527	− 3.9931	− 3.9846	− 3.9889	+189.1988	....	− 8.5	+ 83.3	72.2
351 to 352	2.064	929.591	− 2.9637	− 2.9695	− 2.9666	+186.2322	....	+ 5.8	+ 89.1	33.6
352 to 353	0.676	930.267	+ 1.3612	+ 1.3625	+ 1.3619	+187.5941	....	− 1.3	+ 87.8	1.7
353 to XLI	0.909	931.176	+ 2.5886	+ 2.5915	+ 2.5900	+190.1841	36.8	− 3.1	+ 84.7	9.6
XLI to 354	2.633	933.809	+ 9.4362	+ 9.4327	+ 9.4344	+199.6185	....	+ 3.5	+ 88.2	12.2
354 to 355	1.792	935.601	+10.5093	+10.4992	+10.5043	+210.1228	....	+10.1	+ 98.3	102.0
355 to 356	2.452	938.053	− 0.1382	− 0.1324	− 0.1353	+209.9875	....	− 5.8	+ 92.5	33.6
356 to 357	0.693	938.746	− 7.3025	− 7.3040	− 7.3033	+202.6842	....	+ 1.5	+ 94.0	2.2
357 to XLII	0.994	939.740	− 9.4945	− 9.4863	− 9.4904	+193.1938	37.2	− 8.2	+ 85.8	67.2
XLII to 358	0.958	940.698	− 8.0547	− 8.0621	− 8.0584	+185.1354	....	+ 7.4	+ 93.2	54.8
358 to 359	2.180	942.878	+ 0.2132	+ 0.2111	+ 0.2122	+185.3476	....	+ 2.1	+ 95.3	4.4
359 to 360	1.230	944.108	+ 0.7471	+ 0.7501	+ 0.7486	+186.0962	....	− 3.0	+ 92.3	9.0
360 to XLIII	1.667	945.775	− 1.1685	− 1.1675	− 1.1680	+184.9282	37.3	− 1.0	+ 91.3	1.0
XLIII to 361	2.092	947.867	+ 1.0665	+ 1.0660	+ 1.0662	+185.9944	....	+ 0.5	+ 91.8	0.2
361 to 362	1.669	949.536	− 0.2438	− 0.2520	− 0.2479	+185.7465	....	+ 8.2	+100.0	67.2
362 to 367	1.700	951.236	+ 0.3803	+ 0.3892	+ 0.3848	+186.1313	....	− 8.9	+ 91.1	79.2
367 to XLVIII	2.862	954.098	+ 1.6002	+ 1.5988	+ 1.5995	+187.7308	37.5	+ 1.4	+ 92.5	2.0
XLVIII to 366	1.508	955.606	− 0.0775	− 0.0739	− 0.0757	+187.6551	....	− 3.6	+ 88.9	13.0
366 to XLVII	1.441	957.047	+ 0.4000	+ 0.4053	+ 0.4027	+188.0578	37.5	− 5.3	+ 83.6	28.1
XLVII to 363	2.187	959.234	+ 0.5199	+ 0.5185	+ 0.5192	+188.5770	....	+ 1.4	+ 85.0	2.0
363 to XLIV	1.846	961.080	− 0.2408	− 0.2336	− 0.2372	+188.3398	37.6	− 7.2	+ 77.8	51.8
XLIV to XLV	2.031	963.111	+ 1.3835	+ 1.3871	+ 1.3853	+189.7251	37.6	− 3.6	+ 74.2	13.0
XLV to 364	0.862	963.973	+ 0.1374	+ 0.1323	+ 0.1348	+189.8599	....	+ 5.1	+ 79.3	26.0
364 to XLVI	1.916	965.889	+ 0.4416	+ 0.4341	+ 0.4379	+190.2978	37.8	+ 7.5	+ 86.8	56.2
XLVI to 365	1.876	967.765	+ 1.0180	+ 1.0150	+ 1.0165	+191.3143	....	+ 3.0	+ 89.8	9.0
365 to XLIX	1.578	969.343	+ 0.9850	+ 0.9796	+ 0.9823	+192.2966	37.8	+ 5.4	+ 95.2	29.2
XLIX to 368	1.896	971.239	+ 0.5598	+ 0.5592	+ 0.5595	+192.8561	... .	+ 0.6	+ 95.8	0.4
368 to 369	2.044	973.283	+ 0.8281	+ 0.8280	+ 0.8280	+193.6841	....	+ 0.1	+ 95.9	0.0
369 to 370	2.434	975.717	− 0.8604	− 0.8671	− 0.8637	+192.8204	....	+ 6.7	+102.6	44.9
370 to L (50)	1.718	977.435	+ 5.2218	+ 5.2182	+ 5.2200	+198.0404	37.9	+ 3.6	+106.2	13.0
L (50) to P	0.147	977.582	+ 2.1142	+ 2.1142	+ 2.1142	+200.1546	37.9	0.0	+106.2	0.0

SECTION III.—*Description of primary and secondary bench-marks between Grafton, W. Va., and Athens, Ohio.*

M—Grafton, W. Va. Cut on top of the north side of the central pier of the Baltimore and Ohio Railroad bridge over Taggart's Valley Creek, a branch of the Monongahela River. It is marked thus:

M
B □ M
U. S. C. S.
1878

No. XXXI—About $5\frac{1}{2}$ miles west of Grafton, W. Va. Cut on corner-stone of the east end of a trestle which is numbered $2\frac{1}{2}$ (Baltimore and Ohio Railroad, Parkersburg branch). It is marked thus: B □ M.

No. XXXII—Cut on corner-stone of the west abutment of the Baltimore and Ohio Railroad bridge east of Bridgeport, Harrison County, West Virginia. It is marked thus: B □ M.

No. XXXIII—About 2 miles east of West Union, Doddridge County, West Virginia. Cut on top of the pier at the west end of Baltimore and Ohio Railroad bridge No. 21, over Middle Island Creek. It is marked thus: B □ M.

N—About one-fourth mile east of West Union, W. Va., and is cut on the top of the southwest corner of the pier of Baltimore and Ohio Railroad bridge No. 23, over Middle Island Creek. It is marked thus:

N
B □ M
U. S. C. & G. S.
1878

No. XXXIV—Cut on the southeast corner stone of the pier of bridge No. 26 (Baltimore and Ohio Railroad), about 10 miles west of West Union, W. Va., and is marked thus: B □ M.

No. XXXV—Cut on the coping-stone of the eastern abutment of Baltimore and Ohio Railroad bridge No. 31, over Bond's Creek, about one-fourth mile east of Cornwall Station. It is marked thus: B □ M.

No. XXXVI—Cut on the eastern abutment of Baltimore and Ohio Railroad bridge No. 35, over Bond's Creek, 1 mile east of Cairo, Ritchie County, West Virginia. It is marked thus: B □ M.

No. XXXVII—Cut on the west abutment of Baltimore and Ohio Railroad bridge over Goose Creek, about 200 metres east of Petroleum, W. Va. It is marked thus: B □ M.

No. XXXVIII—Cut on the northeast corner-stone of abutment of Baltimore and Ohio Railroad bridge No. 44, about 1 mile west of Petroleum, W. Va. It is marked thus: B □ M.

No. XXXIX—Cut on the foundation at northwest corner of Baltimore and Ohio Railroad bridge No. 52, 2 miles east of Parkersburg, W. Va.

O—At Parkersburg, W. Va. Cut on the water-table, south front, near western corner, of the post-office and court-house. It is marked thus:

O
B □ M
U. S. C. & G. S.
1878

No. XL—Belpre, Ohio. Cut on the wing-wall of the second pier from west end of Baltimore and Ohio Railroad bridge, which crosses the Ohio River at this point. It is marked thus: B □ M.

No. XLI—Cut on southwest corner of abutment of Marietta and Cincinnati Railroad bridge over Little Hocking Creek, near its junction with the Ohio River, and at Little Hocking Station. It is marked thus: B □ M.

No. XLII—About one-half mile east of Coolville Station, Marietta and Cincinnati Railroad. Cut on coping of abutment of a railroad bridge, and is marked thus: B □ M.

No. XLIII—About $3\frac{3}{4}$ miles west of Coolville, Athens County, Ohio. Cut on east abutment of a small railroad bridge, and is marked thus: B □ M.

No. XLIV—About 1 mile west of Guysville, Ohio, and is cut on the eastern abutment of Marietta and Cincinnati Railroad bridge, and marked thus: B □ M.

No. XLV—Cut on the west abutment of Marietta and Cincinnati Railroad bridge over Little Hocking River, about 2½ miles west of Guysville, Ohio, and is marked thus: B □ M.

No. XLVI—Cut on the west abutment of a small bridge (Marietta and Cincinnati Railroad), about 150 metres east of "Canaan Chapel," Canaanville, Athens County, Ohio. It is marked thus: B □ M.

No. XLVII—About three-fourths of a mile west of Stewart, Athens County, Ohio. Cut on the west abutment of Marietta and Cincinnati Railroad bridge over Little Hocking River. It is marked thus: B □ M.

No. XLVIII—One and one-fourth miles east of Stewart, Athens County, Ohio. Cut on top of the wall of the west abutment of Marietta and Cincinnati Railroad bridge, and is marked thus: B □ M.

No. XLIX—Cut on the coping of a railroad culvert, about 1½ miles west of Canaanville, Athens County, Ohio, and is marked thus: B □ M.

No. L—Cut on the south abutment (east side and fourth step from top) of road bridge over Marietta and Cincinnati Railroad and the Hockhocking River at Athens, Ohio. It is marked thus: B □ M.

P—Athens, Ohio. Cut on top of the pier of the bridge over the Marietta and Cincinnati Railroad and the Hockhocking River, and is marked thus:

P
B □ M
U. S. C. S.
1878

Transcontinental line of Spirit-levels—Continued.

SECTION IV.—FROM ATHENS, OHIO, TO MITCHELL, IND.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod A, first line.	Rod B, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ²
	km.	km.	m.	m.	m.	m.	±mm.	mm.	mm.	(mm)²
P	....	977.582	....	....	....	+200.1546	37.9	....	+106.2	......
P to 1	1.447	979.029	− 0.8493	− 0.8453	− 0.8473	+199.3073	....	− 4.0	+102.2	16.0
1 to 2	1.813	980.842	+ 0.0606	+ 0.0676	+ 0.0641	+199.3714	....	− 7.0	+ 95.2	49.0
2 to 3	1.282	982.124	+ 1.4109	+ 1.4075	+ 1.4092	+200.7806	....	+ 3.4	+ 98.6	11.6
3 to 4	1.699	983.823	+ 8.4320	+ 8.4396	+ 8.4358	+209.2164	....	− 7.6	+ 91.0	57.8
4 to 5	1.293	985.116	− 1.5909	− 1.5922	− 1.5916	+207.6248	....	+ 1.3	+ 92.3	1.7
5 to 6	1.523	986.639	+14.3414	+14.3494	+14.3454	+221.9702	....	− 8.0	+ 84.3	64.0
6 to 7	2.527	989.166	+25.4324	+25.4386	+25.4355	+247.4057	....	− 6.2	+ 78.1	38.4
7 to 8	0.595	989.761	+ 1.8004	+ 1.8035	+ 1.8020	+249.2077	....	− 3.1	+ 75.0	9.6
8 to 10	3.366	993.127	−27.3858	−27.3919	−27.3889	+221.8188	....	+ 6.1	+ 81.1	37.2
10 to 9	1.185	994.312	− 3.3943	− 3.3957	− 3.3950	+218.4238	....	+ 1.4	+ 82.5	2.0
9 to 12	1.470	995.782	+ 0.9569	+ 0.9564	+ 0.9567	+219.3805	....	+ 0.5	+ 83.0	0.2
12 to 11	2.332	998.114	− 5.1541	− 5.1547	− 5.1544	+214.2261	....	+ 0.6	+ 83.6	0.4
11 to LI	2.405	1000.519	+ 3.0152	+ 3.0146	+ 3.0149	+217.2410	38.4	+ 0.6	+ 84.2	0.4
LI to 13	2.194	1002.713	− 3.2828	− 3.2782	− 3.2805	+213.9605	....	− 4.6	+ 79.6	21.2
13 to 14	2.202	1004.915	+ 0.4068	+ 0.3994	+ 0.4031	+214.3636	....	+ 7.4	+ 87.0	54.8
14 to 15	3.136	1008.051	+ 1.9142	+ 1.9123	+ 1.9132	+216.2768	....	+ 1.9	+ 88.9	3.6
15 to LII	2.959	1011.010	+ 1.6157	+ 1.6202	+ 1.6180	+217.8948	38.5	− 4.5	+ 84.4	20.3
LII to 17	1.884	1012.894	+ 7.7143	+ 7.7185	+ 7.7164	+225.6112	....	− 4.2	+ 80.2	17.6
17 to 16	2.808	1015.702	−10.8643	−10.8697	−10.8670	+214.7442	....	+ 5.4	+ 85.6	29.2
16 to 18	3.123	1018.825	+14.5309	+14.3558	+14.5334	+229.2776	....	− 4.9	+ 80.7	24.0
18 to 19	2.320	1021.145	− 2.7059	− 2.7102	− 2.7081	+226.5695	....	− 4.3	+ 76.4	18.5
19 to 20	2.852	1023.997	− 2.7417	− 2.7361	− 2.7389	+223.8306	....	− 5.6	+ 70.8	31.4
20 to LIII	3.202	1027.199	− 8.4063	− 8.4066	− 8.4064	+215.4242	38.7	+ 0.3	+ 71.1	0.1
LIII to 21	1.157	1028.356	+ 1.9727	+ 1.9742	+ 1.9734	+217.3976	....	− 1.5	+ 69.6	2.2

Transcontinental line of Spirit-levels—Continued.

SECTION IV.—FROM ATHENS, OHIO, TO MITCHELL, IND.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod A, first line.	Rod B, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ²
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	±*mm.*	*mm.*	*mm.*	(*mm.*)²
21 to 22	2.801	1031.157	+ 9.3109	+ 9.3082	+ 9.3096	+226.7072	......	+ 2.7	+ 72.3	7.3
22 to 23	2.023	1033.180	+10.4067	+10.4158	+10.4112	+237.1184	......	− 9.1	+ 63.2	82.8
23 to 24	1.868	1035.048	− 8.6092	− 8.6161	− 8.6126	+228.5058	......	+ 6.9	+ 70.1	47.6
24 to 25	2.061	1037.109	−14.7564	−14.7486	−14.7525	+213.7533	......	− 7.8	+ 62.3	60.8
25 to 26	0.869	1037.978	− 3.7108	− 3.7136	− 3.7122	+210.0411	......	+ 2.8	+ 65.1	7.8
26 to 27	1.368	1039.346	− 5.7052	− 5.7049	− 5.7051	+204.3360	......	− 0.3	+ 64.8	0.1
27 to 28	3.862	1043.208	−14.4579	−14.4621	−14.4600	+189.8760	......	+ 4.2	+ 69.0	17.6
28 to 29	2.950	1046.158	− 2.2281	− 2.2323	− 2.2302	+187.6458	......	+ 4.2	+ 73.2	17.6
29 to 30	0.631	1046.789	− 1.8801	− 1.8770	− 1.8784	+185.7674	......	− 3.1	+ 70.1	9.6
30 to 31	3.135	1049.924	− 2.0535	− 2.0462	− 2.0499	+183.7175	......	− 7.3	+ 62.8	53.2
31 to 32	2.584	1052.508	+ 0.6817	+ 0.6780	+ 0.6799	+184.3974	......	+ 3.7	+ 66.5	13.7
32 to LIV	2.027	1054.535	− 1.1455	− 1.1484	− 1.1470	+183.2504	39.2	+ 2.9	+ 69.4	8.4
LIV to 33	2.418	1056.953	+ 3.5396	+ 3.5403	+ 3.5400	+186.7904	......	− 0.7	+ 68.7	0.5
33 to 36	0.821	1057.774	+ 6.4447	+ 6.4433	+ 6.4440	+193.2344	......	+ 1.4	+ 70.1	2.0
36 to 35	2.241	1060.015	+20.1473	+20.1504	+20.1489	+213.3833	......	− 3.1	+ 67.0	9.6
35 to LV	1.570	1061.585	−12.7770	−12.7803	−12.7787	+200.6046	39.2	+ 3.3	+ 70.3	10.9
LV to 34	2.580	1064.165	+ 1.9054	+ 1.9007	+ 1.9031	+202.5077	......	+ 4.7	+ 75.0	22.1
34 to 37	2.777	1066.942	− 3.9738	− 3.9741	− 3.9740	+198.5337	......	+ 0.3	+ 75.3	0.1
37 to 38	2.463	1069.405	− 5.3983	− 5.3976	− 5.3979	+193.1358	......	− 0.7	+ 74.6	0.5
38 to 41	1.343	1070.748	− 7.5024	− 7.5067	− 7.5046	+185.6312	......	+ 4.3	+ 78.9	18.5
41 to 40	2.760	1073.508	+ 0.2594	+ 0.2587	+ 0.2591	+185.8903	......	+ 0.7	+ 79.6	0.5
40 to 39	2.757	1076.265	+ 5.2173	+ 5.2192	+ 5.2183	+191.1086	......	− 1.7	+ 77.9	2.9
39 to 42	1.040	1077.305	+ 2.9375	+ 2.9418	+ 2.9396	+194.0482	......	− 4.3	+ 73.6	18.5
42 to Q	0.113	1077.418	+ 0.5909	+ 0.5925	+ 0.5917	+194.6399	39.3	− 1.6	+ 72.0	2.6
42 to 43	0.574	1077.879	− 0.5028	− 0.5034	− 0.5031	+193.5513	......	+ 0.6	+ 72.6	0.4
43 to 44	1.898	1079.777	+ 3.0179	+ 3.0146	+ 3.0163	+196.5676	......	+ 3.3	+ 75.9	10.9
44 to 45	2.370	1082.147	+14.5119	+14.5108	+14.5113	+211.0789	......	+ 1.1	+ 77.0	1.2
45 to 46	1.318	1083.465	+13.3850	+13.3831	+13.3841	+224.4630	......	+ 1.9	+ 78.9	3.6
46 to 47	3.048	1086.513	−11.4466	−11.4530	−11.4498	+213.0132	......	+ 6.4	+ 85.3	41.0
47 to 48	1.273	1087.786	− 1.2272	− 1.2315	− 1.2294	+211.7838	......	+ 4.3	+ 89.6	18.5
48 to LVI	3.447	1091.233	+ 1.6395	+ 1.6427	+ 1.6411	+213.4249	39.4	− 3.2	+ 86.4	10.2
LVI to LVII	2.658	1093.891	+ 3.8251	+ 3.8176	+ 3.8214	+217.2463	39.4	+ 7.5	+ 93.9	56.5
LVII to 49	1.642	1095.533	+ 3.3990	+ 3.3967	+ 3.3978	+220.6441	......	+ 2.3	+ 96.2	5.3
49 to 50	2.215	1097.748	+ 7.9542	+ 7.9574	+ 7.9558	+228.5999	......	− 3.2	+ 93.0	10.2
50 to 51	2.037	1099.785	+15.9381	+15.9358	+15.9370	+244.5369	......	+ 2.3	+ 95.3	5.3
51 to 52	2.235	1102.020	+21.3782	+21.3784	+21.3783	+265.9152	......	− 0.2	+ 95.1	0.0
52 to 53	2.315	1104.335	+17.7174	+17.7119	+17.7146	+283.6298	......	+ 5.5	+100.6	30.2
53 to 54	0.593	1104.928	+ 2.6032	+ 2.6020	+ 2.6026	+286.2324	......	+ 1.2	+101.8	1.4
54 to 55	1.821	1106.749	− 3.9766	− 3.9774	− 3.9770	+282.2554	......	+ 0.8	+102.6	0.6
55 to LVIII	1.317	1108.066	− 4.2102	− 4.2107	− 4.2104	+278.0450	39.6	+ 0.5	+103.1	0.3
LVIII to 56	1.914	1109.980	− 2.0490	− 2.0444	− 2.0467	+275.9983	....	− 4.6	+ 98.5	21.2
56 to 57	1.904	1111.884	+ 8.3201	+ 8.3102	+ 8.3151	+284.3134	......	+ 9.9	+108.4	98.0
57 to 58	2.227	1114.111	−10.7835	−10.7824	−10.7829	+273.5305	......	− 1.1	+107.3	1.2
58 to 59	0.532	1114.643	− 5.3906	− 5.3922	− 5.3914	+268.1391	......	+ 1.6	+108.9	2.6
59 to 65	1.929	1116.572	+11.2037	+11.2017	+11.2027	+279.3418	......	+ 2.0	+110.9	4.0
65 to 64	2.676	1119.248	+13.3042	+13.2940	+13.2991	+292.6409	......	+10.2	+121.1	104.0
64 to 63	1.784	1121.032	+ 4.5179	+ 4.5104	+ 4.5141	+297.1550	......	+ 7.5	+128.6	56.5
63 to 62	1.987	1123.019	−17.4198	−17.4149	−17.4173	+279.7377	......	− 4.9	+123.7	24.0
62 to 61	0.767	1123.786	+ 7.3481	+ 7.3480	+ 7.3480	+287.0857	......	+ 0.1	+123.8	0.0
61 to 60	2.183	1125.969	+ 6.3334	+ 6.3264	+ 6.3299	+293.4156	......	+ 7.0	+130.8	49.0
60 to 66	1.758	1127.727	− 1.9496	− 1.9495	− 1.9496	+291.4660	......	− 0.1	+130.7	0.0
66 to 67	1.725	1129.452	+ 7.3610	+ 7.3642	+ 7.3626	+298.8286	......	− 3.2	+127.5	10.2
67 to 68	1.112	1130.564	+10.9462	+10.9428	+10.9445	+309.7731	......	+ 3.4	+130.9	11.6
68 to 71	2.017	1132.581	+ 6.9469	+ 6.9494	+ 6.9482	+316.7213	......	− 2.5	+128.4	6.2
71 to 72	0.612	1133.193	+ 3.3874	+ 3.3874	+ 3.3874	+320.1087	......	0.0	+128.4	0.0
72 to 73	1.656	1134.849	+ 8.0193	+ 8.0203	+ 8.0198	+328.1285	......	− 1.0	+127.4	1.0

Transcontinental line of Spirit-levels—Continued.

SECTION IV.—FROM ATHENS, OHIO, TO MITCHELL, IND.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks.			•Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy.		Δ^2
			Rod A, first line.	Rod B, second line.	Mean.			Partial Δ	Total.	
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	(*mm.*)²
73 to 75	1.749	1136.598	+ 8.9500	+ 8.9521	+ 8.9510	+337.0795	......	− 2.1	+125.3	4.4
75 to 76	1.760	1138.358	+ 0.7337	+ 0.7371	+ 0.7354	+337.8149	......	− 3.4	+121.9	11.6
76 to 77	1.619	1139.977	+10.8087	+10.8073	+10.8080	+348.6229	......	+ 1.4	+123.3	2.0
77 to 69	1.627	1141.604	+ 2.8393	+ 2.8386	+ 2.8390	+351.4619	......	+ 0.7	+124.0	0.5
69 to 70	2.488	1144.092	−10.8359	−10.8339	+10.8349	+340.6270	......	− 2.0	+122.0	4.0
70 to 74	2.063	1146.155	− 5.3463	− 5.3438	− 5.3451	+335.2819	......	− 2.5	+119.5	6.2
74 to 80	1.731	1147.886	−14.6184	−14.6204	−14.6194	+320.6625	......	+ 2.0	+121.5	4.0
80 to 79	2.758	1150.644	+ 2.9832	+ 2.9824	+ 2.9828	+323.6453	......	+ 0.8	+122.3	0.6
79 to 78	1.893	1152.537	+ 9.6357	+ 9.6328	+ 9.6343	+333.2796	......	+ 2.9	+125.2	8.4
78 to LIX	1.773	1154.310	−11.0715	−11.0705	−11.0710	+322.2086	40.2	− 1.0	+124.2	1.0
LIX to 81	1.814	1156.124	−10.3902	−10.3892	−10.3897	+311.8189	......	− 1.0	+123.2	1.0
81 to 82	2.132	1158.256	− 3.6095	− 3.6048	− 3.6072	+308.2117	......	− 4.7	+118.5	22.1
82 to 83	2.115	1160.371	− 2.0586	− 2.0617	− 2.0601	+306.1516	......	+ 3.1	+121.6	9.6
83 to LX	2.089	1162.460	− 4.2311	− 4.2363	− 4.2337	+301.9179	40.3	+ 5.2	+126.8	27.0
LX to 84	1.514	1163.974	+ 1.4515	+ 1.4534	+ 1.4524	+303.3703	......	− 1.9	+124.9	3.6
84 to 85	1.797	1165.771	+ 2.0840	+ 2.0850	+ 2.0845	+305.4548	......	− 1.0	+123.9	1.0
85 to 86	1.831	1167.602	− 2.4145	− 2.4122	− 2.4133	+303.0415	......	− 2.3	+121.6	5.3
86 to 87	1.775	1169.377	− 9.1419	− 9.1369	− 9.1394	+293.9021	......	− 5.0	+116.6	25.0
87 to 88	1.840	1171.217	− 6.8339	− 6.8315	− 6.8327	+287.0694	......	− 2.4	+114.2	5.8
88 to 89	2.031	1173.248	+ 1.1142	+ 1.1113	+ 1.1127	+288.1821	......	+ 2.9	+117.1	8.4
89 to 93	1.876	1175.124	− 8.5435	− 8.5413	− 8.5424	+279.6397	......	− 2.2	+114.9	4.8
93 to 94	2.223	1177.347	− 5.7499	− 5.7478	− 5.7488	+273.8909	......	− 2.1	+112.8	4.4
94 to 95	1.717	1179.064	− 6.0326	− 6.0312	− 6.0319	+267.8590	......	− 1.4	+111.4	2.0
95 to 96	1.776	1180.840	+ 2.7743	+ 2.7748	+ 2.7745	+270.6335	......	− 0.5	+110.9	0.3
96 to 97	2.254	1183.094	− 7.0677	− 7.0631	− 7.0654	+263.5681	......	− 4.6	+106.3	21.2
97 to 98	1.749	1184.843	−14.9108	−14.9032	−14.9070	+248.6611	......	− 7.6	+ 98.7	57.8
98 to 99	2.570	1187.413	−20.3289	−20.3290	−20.3289	+228.3322	......	+ 0.1	+ 98.8	0.0
99 to 100	0.565	1187.978	− 4.8023	− 4.8022	− 4.8023	+223.5299	......	− 0.1	+ 98.7	0.0
100 to LXI	2.119	1190.097	−12.1865	−12.1808	−12.1836	+211.3463	40.5	− 5.7	+ 93.0	32.5
LXI to 102	1.090	1191.187	−10.0242	−10.0311	−10.0277	+201.3186	......	+ 6.9	+ 99.9	47.6
102 to 103	2.377	1193.564	−16.1987	−16.1969	−16.1978	+185.1208	......	− 1.8	+ 98.1	3.2
103 to 92	1.349	1194.913	− 6.6781	− 6.6735	− 6.6758	+178.4450	......	− 4.6	+ 93.5	21.2
92 to R	0.429	1195.342	− 0.9451	− 0.9471	− 0.9461	+177.4989	40.6	+ 2.0	+ 95.5	4.0
R to 91	2.032	1197.374	− 0.3825	− 0.3889	− 0.3857	+177.1132	......	+ 6.4	+101.9	41.0
91 to 90	1.727	1199.101	− 2.4133	− 2.4073	− 2.4103	+174.7029	......	− 6.0	+ 95.9	36.0
90 to 104	2.094	1201.195	+ 3.8305	+ 3.8232	+ 3.8269	+178.5298	......	+ 7.3	+103.2	53.3
104 to LXII	2.198	1203.393	+ 1.7034	+ 1.7035	+ 1.7034	+180.2332	40.8	+ 0.1	+103.1	0.0
LXII to 106	1.973	1205.366	+19.9105	+19.9117	+19.9111	+200.1443	......	− 1.2	+111.9	1.4
106 to 107	1.589	1206.955	+16.1168	+16.1199	+16.1184	+216.2627	......	− 3.1	+108.8	9.6
107 to 108	2.641	1209.596	+ 3.9260	+ 3.9296	+ 3.9278	+220.1905	......	− 3.6	+105.2	13.0
108 to 109	0.800	1210.396	− 7.5684	− 7.5679	− 7.5682	+212.6223	......	− 0.5	+104.7	0.2
109 to 110	3.259	1213.655	−32.6422	−32.6371	−32.6396	+179.9827	......	− 5.1	+ 99.6	26.0
110 to 111	2.566	1216.221	+ 7.1306	+ 7.1343	+ 7.1324	+187.1151	......	− 3.7	+ 95.9	13.7
111 to 112	2.517	1218.738	− 1.7178	− 1.7168	− 1.7173	+185.3978	......	− 1.0	+ 94.9	1.0
112 to 113	3.176	1221.914	−16.3209	−16.3233	−16.3221	+169.0757	......	+ 2.4	+ 97.3	5.8
113 to 114	0.885	1222.799	− 5.1658	− 5.1688	− 5.1673	+163.9084	......	+ 3.0	+100.3	9.0
114 to 115	1.958	1224.757	−12.1350	−12.1292	−12.1321	+151.7763	......	− 5.8	+ 94.5	33.6
115 to LXIII	2.419	1227.176	+ 2.7153	+ 2.7125	+ 2.7139	+154.4902	41.0	+ 2.8	+ 97.3	7.8
LXIII to 116	1.490	1228.666	− 3.6049	− 3.6049	− 3.6049	+150.8853	......	0.0	+ 97.3	0.0
116 to LXIV	3.622	1232.288	+ 0.0633	+ 0.0671	+ 0.0652	+150.9505	41.0	− 3.8	+ 93.5	14.4
LXIV to S	0.302	1232.590	− 0.1039	− 0.1015	− 0.1027	+150.8478	41.0	− 2.4	+ 91.1	5.8
S to 122	2.505	1235.095	+17.1825	+17.1870	+17.1848	+168.0326	......	− 4.5	+ 86.6	20.3
122 to T	0.681	1235.776	− 1.3158	− 1.3159	− 1.3159	+166.7167	41.0	+ 0.1	+ 86.7	0.0
S to 121	2.083	1234.673	− 2.5429	− 2.5441	− 2.5435	+148.3043	......	+ 1.2	+ 92.3	1.4
121 to 120	2.686	1237.359	+ 0.2496	+ 0.2476	+ 0.2486	+148.5529	......	+ 2.0	+ 94.3	4.0
120 to 119	1.861	1239.220	− 0.2426	− 0.2502	− 0.2464	+148.3065	......	+ 7.6	+101.9	57.8

Transcontinental line of Spirit-levels—Continued.

SECTION IV.—FROM ATHENS, OHIO, TO MITCHELL, IND.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod A, first line.	Rod B, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ²
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	(*mm.*)²
119 to 118	3.013	1242.233	− 0.1115	− 0.1062	− 0.1088	+148.1977	....	− 5.3	+ 96.6	28.1
118 to 117	3.117	1245.350	− 0.1987	− 0.2048	− 0.2018	+147.9959	....	+ 6.1	+102.7	37.2
117 to LXV	2.226	1247.576	+ 0.8732	+ 0.8773	+ 0.8753	+148.8712	41.2	− 4.1	+ 98.6	16.8
LXV to 123	2.546	1250.122	+ 0.2071	+ 0.2056	+ 0.2063	+149.0775	....	+ 1.5	+100.1	2.2
123 to 124	2.493	1252.615	− 0.7199	− 0.7131	− 0.7165	+148.3610	....	− 6.8	+ 93.3	46.2
124 to 125	3.713	1256.328	− 0.3951	− 0.3921	− 0.3936	+147.9674	....	− 3.0	+ 90.3	9.0
125 to 126	2.297	1258.625	+ 1.6776	+ 1.6751	+ 1.6764	+149.6438	....	+ 2.5	+ 92.8	6.2
126 to 127	3.403	1262.028	− 1.6373	− 1.6339	− 1.6356	+148.0082	....	− 3.4	+ 89.4	11.6
127 to LXVI	0.706	1262.734	− 0.8103	− 0.8085	− 0.8094	+147.1988	41.3	− 1.8	+ 87.6	3.2
LXVI to 128	3.120	1265.854	− 1.6681	− 1.6689	− 1.6685	+145.5303	....	+ 0.8	+ 88.4	0.6
128 to 135	0.478	1266.332	+ 0.6589	+ 0.6560	+ 0.6574	+146.1877	....	+ 2.9	+ 91.3	8.4
135 to U	0.117	1266.449	+ 2.0857	+ 2.0852	+ 2.0855	+148.2732	41.3	+ 0.5	+ 91.8	0.2
135 to 134	2.330	1268.662	− 0.7465	− 0.7447	− 0.7456	+145.4421	....	− 1.8	+ 89.5	3.2
134 to 133	2.075	1270.737	+ 0.2904	+ 0.2953	+ 0.2928	+145.7349	....	− 4.9	+ 84.6	24.0
133 to 132	1.924	1272.661	+ 5.9936	+ 5.9946	+ 5.9941	+151.7290	....	− 1.0	+ 83.6	1.0
132 to 131	2.310	1274.971	− 3.5296	− 3.5334	− 3.5315	+148.1975	....	+ 3.8	+ 87.4	14.4
131 to 130	1.218	1276.189	+ 0.6357	+ 0.6386	+ 0.6372	+148.8347	....	− 2.9	+ 84.5	8.4
130 to 129	1.913	1278.102	− 0.6046	− 0.6013	− 0.6030	+148.2317	....	− 3.3	+ 81.2	10.9
129 to LXVII	2.133	1280.235	+ 2.3783	+ 2.3730	+ 2.3757	+150.6074	41.4	+ 5.3	+ 86.5	28.1
LXVII to 136	3.654	1283.889	+21.0770	+21.0774	+21.0772	+171.6846	....	− 0.4	+ 86.1	0.2
136 to 137	1.483	1285.372	+12.5046	+12.4974	+12.5010	+184.1856	....	+ 7.2	+ 93.3	51.8
137 to 141	2.087	1287.459	+18.5276	+18.5314	+18.5295	+202.7151	....	− 3.8	+ 89.5	14.4
141 to 142	3.266	1290.725	+31.9681	+31.9720	+31.9700	+234.6851	....	− 3.9	+ 85.6	15.2
142 to 143	1.957	1292.682	+18.6616	+18.6608	+18.6612	+253.3463	....	+ 0.8	+ 86.4	0.6
143 to 144	3.082	1295.764	+26.3473	+26.3462	+26.3468	+279.6931	....	+ 1.1	+ 87.5	1.2
144 to 145	3.827	1299.591	+21.4459	+21.4482	+21.4470	+301.1401	....	− 2.3	+ 85.2	5.3
145 to 146	0.957	1300.548	+ 3.4677	+ 3.4636	+ 3.4657	+304.6058	....	+ 4.1	+ 89.3	16.8
146 to 147	2.169	1302.717	+ 0.4087	+ 0.4112	+ 0.4099	+305.0157	....	− 2.5	+ 86.8	6.2
147 to LXVIII	3.990	1306.707	−21.9792	−21.9785	−21.9788	+283.0369	41.6	− 0.7	+ 86.1	0.5
LXVIII to 138	2.942	1309.649	−16.0553	−16.0566	−16.0560	+266.9809	....	+ 1.3	+ 87.4	1.7
138 to 139	3.139	1312.788	+10.1448	+10.1497	+10.1473	+277.1282	....	− 4.9	+ 82.5	24.0
139 to 140	0.572	1313.360	+ 5.2413	+ 5.2416	+ 5.2414	+282.3696	....	− 0.3	+ 82.2	0.1
140 to 148	2.521	1315.881	+20.0879	+20.0867	+20.0873	+302.4569	....	+ 1.2	+ 83.4	1.4
148 to 150	2.862	1318.743	− 4.9439	− 4.9462	− 4.9450	+297.5119	....	+ 2.3	+ 85.7	5.3
150 to 149	2.937	1321.680	− 4.6357	− 4.6357	− 4.6357	+292.8762	....	0.0	+ 85.7	0.0
149 to 151	2.466	1324.146	−14.9216	−14.9136	−14.9176	+277.9586	....	− 8.0	+ 77.7	64.0
151 to 152	2.794	1326.940	− 1.3745	− 1.3781	− 1.3763	+276.5823	....	+ 3.6	+ 81.3	13.0
152 to 153	2.077	1329.017	−16.1173	−16.1229	−16.1201	+260.4622	....	+ 5.6	+ 86.9	31.4
153 to 154	1.879	1330.896	− 7.3402	− 7.3321	− 7.3361	+253.1261	....	− 8.1	+ 78.8	65.6
154 to 155	3.293	1334.189	+ 0.8370	+ 0.8386	+ 0.8378	+253.9639	....	− 1.6	+ 77.2	2.6
155 to 156	1.959	1336.148	− 6.0772	− 6.0813	− 6.0793	+247.8846	....	+ 4.1	+ 81.3	16.8
156 to 157	2.539	1338.687	− 0.7785	− 0.7764	− 0.7774	+247.1072	....	− 2.1	+ 79.2	4.4
157 to 158	0.685	1339.372	− 2.0041	− 2.0072	− 2.0057	+245.1015	....	+ 3.1	+ 82.3	9.6
158 to 159	2.157	1341.529	−11.8845	−11.8824	−11.8835	+233.2180	....	− 2.1	+ 80.2	4.4
159 to 160	2.790	1344.319	− 6.6481	− 6.6523	− 6.6502	+226.5678	....	+ 4.2	+ 84.4	17.6
160 to LXIX	2.993	1347.312	−17.5961	−17.5888	−17.5924	+208.9754	42.0	− 7.3	+ 77.1	53.3
LXIX to 161	1.462	1348.774	+11.6155	+11.6132	+11.6143	+220.5897	....	+ 2.3	+ 79.4	5.3
161 to 162	2.630	1351.404	+ 1.3430	+ 1.3448	+ 1.3439	+221.9336	....	− 1.8	+ 77.6	3.2
162 to 163	3.087	1354.491	−14.6662	−14.6597	−14.6629	+207.2707	....	− 6.5	+ 71.1	42.2
163 to 164	3.404	1357.895	−21.7044	−21.7099	−21.7072	+185.5635	....	+ 5.5	+ 76.6	30.2
164 to 174	3.123	1361.018	+ 1.8883	+ 1.8850	+ 1.8867	+187.4502	....	+ 3.3	+ 79.9	10.9
174 to 168	3.887	1364.905	− 8.8481	− 8.8490	− 8.8486	+178.6016	....	+ 0.9	+ 80.8	0.8
168 to 167	2.212	1367.117	− 3.4400	− 3.4499	− 3.4449	+175.1567	....	+ 9.9	+ 90.7	98.0
167 to 166	2.539	1369.656	+ 7.2820	+ 7.2851	+ 7.2835	+182.4402	....	− 3.1	+ 87.6	9.6
166 to 165	3.002	1372.658	+ 2.9072	+ 2.9131	+ 2.9102	+185.3504	....	− 5.9	+ 81.7	34.8
165 to 173	1.847	1374.505	−11.6258	−11.6271	−11.6265	+173.7239	....	+ 1.3	+ 83.0	1.7
173 to 172	2.617	1377.122	− 2.2776	− 2.2773	− 2.2774	+171.4465	....	− 0.3	+ 82.7	0.1

Transcontinental line of Spirit-levels—Continued.

SECTION IV.—FROM ATHENS, OHIO, TO MITCHELL, IND.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod A, first line.	Rod B, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ.	Total.	Δ²
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	±*mm.*	*mm.*	*mm.*	(*mm.*)²
172 to 171	2.261	1379.383	+ 0.6674	+ 0.6664	+ 0.6669	+172.1134	....	+ 1.0	+83.7	1.0
171 to 170	2.145	1381.528	− 1.5725	− 1.5666	− 1.5696	+170.5438	....	− 5.9	+77.8	34.8
170 to 169	2.039	1383.567	− 1.4206	− 1.4175	− 1.4190	+169.1248	....	− 3.1	+74.7	9.6
169 to 175	2.076	1385.643	+ 0.3842	+ 0.3857	+ 0.3849	+169.5097	....	− 1.5	+73.2	2.2
175 to 176	4.129	1389.772	− 1.1202	− 1.1200	− 1.1201	+168.3896	....	− 0.2	+73.0	0.0
176 to 177	2.415	1392.187	+ 0.3636	+ 0.3678	+ 0.3657	+168.7553	....	− 4.2	+68.8	17.6
177 to 178	1.708	1393.895	− 4.4726	− 4.4721	− 4.4723	+164.2830	....	− 0.5	+68.3	0.2
178 to 179	1.703	1395.598	− 0.7329	− 0.7390	− 0.7359	+163.5471	....	+ 6.1	+74.4	37.2
179 to 180	2.117	1397.715	− 1.2777	− 1.2797	− 1.2787	+162.2684	....	+ 2.0	+76.4	4.0
180 to V	1.333	1399.048	+ 0.7653	+ 0.7673	+ 0.7663	+163.0347	42.5	− 2.0	+74.4	4.0
V to 181	3.217	1402.265	− 2.2499	− 2.2518	− 2.2509	+160.7838	....	+ 1.9	+76.3	3.6
181 to 182	0.961	1403.226	+ 0.5668	+ 0.5685	+ 0.5677	+161.3515	....	− 1.7	+74.6	2.9
182 to 185	2.871	1406.097	− 1.1087	− 1.1143	− 1.1115	+160.2400	....	+ 5.6	+80.2	31.4
185 to 184	2.276	1408.373	+ 0.4700	+ 0.4662	+ 0.4681	+160.7081	....	+ 3.8	+84.0	14.4
184 to 183	2.090	1410.463	− 1.3920	− 1.3854	− 1.3887	+159.3194	....	− 6.6	+77.4	43.6
183 to 186	3.024	1413.487	+ 0.2435	+ 0.2462	+ 0.2448	+159.5642	....	− 2.7	+74.7	7.3
186 to LXX	2.142	1415.629	− 0.2619	− 0.2643	− 0.2631	+159.3011	42.6	+ 2.4	+77.1	5.8
LXX to 187	0.594	1416.223	− 0.4813	− 0.4820	− 0.4816	+158.8195	....	+ 0.7	+77.8	0.5
187 to 188	2.418	1418.641	+ 5.4594	+ 5.4563	+ 5.4578	+164.2773	....	+ 3.1	+80.9	9.6
188 to 189	2.741	1421.382	− 6.7784	− 6.7826	− 6.7805	+157.4968	....	+ 4.2	+85.1	17.6
189 to 190	1.921	1423.303	+ 0.4605	+ 0.4525	+ 0.4565	+157.9533	....	+ 8.0	+93.1	64.0
190 to 191	1.882	1425.185	− 0.8013	− 0.7944	− 0.7978	+157.1555	....	− 6.9	+86.2	47.6
191 to W	1.600	1426.785	+ 0.2032	+ 0.2074	+ 0.2053	+157.3608	42.8	− 4.2	+82.0	17.6
W to 192	0.365	1427.150	− 0.1600	− 0.1571	− 0.1586	+157.2022	....	− 2.9	+79.1	8.4
192 to 196	2.845	1429.995	+14.1549	+14.1562	+14.1556	+171.3578	....	− 1.3	+77.8	1.7
196 to 197	1.610	1431.605	+17.4048	+17.4085	+17.4066	+188.7644	....	− 3.7	+74.1	13.7
197 to 195	1.122	1432.727	+12.1813	+12.1871	+12.1842	+200.9486	....	− 5.8	+68.3	33.6
195 to 194	1.115	1433.842	+ 2.7457	+ 2.7490	+ 2.7474	+203.6960	....	− 6.3	+62.0	39.7
194 to 193	2.308	1436.150	+ 3.4879	+ 3.4869	+ 3.4874	+207.1834	....	+ 1.0	+63.0	1.0
193 to X	0.500	1436.650	+ 2.4980	+ 2.4971	+ 2.4975	+209.6809	43.0	+ 0.9	+63.9	0.8
193 to 200	1.756	1437.906	+ 9.8940	+ 9.8989	+ 9.8964	+217.0798	....	− 4.9	+58.1	24.0
200 to 199	4.288	1442.194	− 7.9892	− 7.9875	− 7.9883	+209.0915	....	− 1.7	+56.4	2.9
199 to 198	2.518	1444.712	− 5.1143	− 5.1141	− 5.1142	+203.9773	43.0	− 0.2	+56.2	0.0

SECTION IV.—Description of primary and secondary bench-marks between *Athens, Ohio, and Mitchell, Ind.*

P—Athens, Ohio. Already described.

No. LI—At Moonville, Ohio. Cut on the eastern abutment of Marietta and Cincinnati Railroad bridge over Raccoon Creek, and is marked thus: B □ M.

No. LII—One mile south of Zaleski, Ohio. Cut on the south abutment of Marietta and Cincinnati Railroad bridge over Raccoon Creek, and is marked thus: B □ M.

No. LIII—Cut on the coping of a small drain or culvert, about one-half mile east of Hamden Station, Marietta and Cincinnati Railroad. It is marked thus: B □ M.

No. LIV—Cut on the east abutment of Marietta and Cincinnati Railroad bridge over Big Salt Creek, about 1½ miles east of Londonderry Station, and is marked: B □ M.

No. LV—One and one-half miles east of Schooley's Station, Marietta and Cincinnati Railroad Cut on the eastern abutment of railroad bridge over Walnut Creek, and is marked thus: B □ M.

Q—Cut on the pedestal of the lamp-post which stands on the north side of the steps of the front entrance of the court-house at Chillicothe, Ohio. It is marked thus:

Q
B □ M
U. S. C. & G. S.
Aug. 5, 1879.

No. LVI—Cut on the west abutment of Marietta and Cincinnati Railroad bridge over branch of Paint Creek, about 1¼ miles east of Musselman's Junction, Ross County, Ohio. It is marked thus: B ◻ M.

No. LVII—Cut on the east abutment of Marietta and Cincinnati Railroad bridge over branch of Paint Creek, about one-fourth mile west of Musselman's Junction, Ross County, Ohio. It is marked thus: B ◻ M.

No. LVIII—Cut on the eastern abutment of Marietta and Cincinnati Railroad bridge, about 1 mile east of Lyndon Station, and is marked thus: B ◻ M.

No. LIX—Cut on the eastern abutment of Marietta and Cincinnati Railroad bridge, at Martinsville, Clinton County, Ohio. It is marked thus: B ◻ M.

No. LX—Cut on the east abutment of Marietta and Cincinnati Railroad bridge, about three-tenths mile east of Clinton Valley Station, and is marked thus: B ◻ M.

No. LXI—Cut on the west abutment of Marietta and Cincinnati Railroad bridge, about 3¼ miles east of Loveland, Ohio, and is marked thus: B ◻ M.

R—Loveland, Ohio. Cut on the east abutment of Marietta and Cincinnati Railroad bridge over the Little Miami River. It is marked thus:

R
B ◻ M
U. S. C. & G. S.
1879.

No. LXII—Cut on the pier of the Marietta and Cincinnati Railroad bridge over Sycamore Creek, a short distance west of Remington Station, and is marked thus: B ◻ M.

No. LXIII—Cut on the west abutment of Marietta and Cincinnati Railroad bridge, a short distance west of Cummingsville, Hamilton County, Ohio. It is marked thus: B ◻ M.

No. LXIV—Cut on the south abutment of Marietta and Cincinnati Railroad bridge over Gest street, suburb of Cincinnati, Ohio. It is marked thus: B ◻ M.

S—Cut on the west abutment of Marietta and Cincinnati Railroad bridge over Mill Creek, at Eighth Street Station, Cincinnati, Ohio. It is marked thus:

S
B ◻ M
U. S. C. & G. S.
1879.

T—Is bench-mark No. 1 of the Cincinnati city engineer, and is on the front water-table of the court-house. It is the centre of the top of a hexagonal copper bolt inserted in the stone.

No. LXV—A square cavity cut in top of a stone monument, about 46 metres west of Delhi Station of Ohio and Mississippi Railroad (Hamilton County, Ohio).

No. LXVI—Hamilton County, Ohio. Cut on a pier (first pier from Ohio side of river) of Ohio and Mississippi Railroad bridge over Miami River, near its junction with the Ohio River. It is about 2 miles east of Lawrenceburg, Ind., and is marked thus: B ◻ M.

U—Lawrenceburg, Ind. Cut on the water-table of the court-house front. It is marked thus:

1879
U. S. C. & G. S.
B ◻ M
U

No. LXVII—Cut on the east abutment of Ohio and Mississippi Railroad bridge No. 11, over South Hogan Creek, about 3½ miles west of Cochran Station, Dearborn County, Indiana. It is marked thus: B ◻ M.

No. LXVIII—Cut on the east abutment of Ohio and Mississippi Railroad bridge over Greasy Run, a short distance east of Delaware, Ripley County, Indiana. It is marked thus: B ◻ M.

No. LXIX—Cut on the east abutment of Ohio and Mississippi Railroad bridge, over north fork of Vernon River, about three-fourths mile east of North Vernon, Jennings County, Indiana. It is marked thus: B ◻ M.

V—Cut on the west abutment of Ohio and Mississippi Railroad bridge over east fork of White River, about 2 miles east of Medora, Jackson County, Indiana. It is marked thus:

V
B □ M
U. S. C. & G. S.
1879.

No. LXX—Cut on the coping stone of arch (Ohio and Mississippi Railroad) over wagon-road, about 200 metres east of Fort Ritner Station, Lawrence County, Indiana. It is marked thus: B □ M.

W—Cut on the eastern abutment of Ohio and Mississippi Railroad bridge over east fork of White River, about one-third mile east of Scottville, Lawrence County, Indiana. It is marked thus:

W
B □ M
U. S. C. & G. S.
1879.

X—Cut on the sill of window near the west corner of the south face of M. N. Moore's store, at Mitchell, Ind. It is marked thus:

X
B □ M
U. S. C. & G. S.
Nov. 19, 1879.

Transcontinental line of Spirit-levels—Continued.

SECTION V.—FROM MITCHELL, IND., TO SAINT LOUIS, MO.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod E, first line.	Rod F, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	(*mm.*)^2
X	....	1436.650	....	....	....	+209.6809	43.0	....	+63.9	....
X to 52	1.238	1437.888	+ 6.7184	+ 6.7165	+ 6.7175	+216.3984	....	+ 1.9	+65.8	3.6
52 to 51	1.796	1439.684	− 3.1796	− 3.1754	− 3.1775	+213.2209	....	− 4.2	+61.6	17.6
51 to 50	1.612	1441.296	+ 6.3682	+ 6.3648	+ 6.3665	+219.5874	....	+ 3.4	+65.0	11.6
50 to 49	2.141	1443.437	−11.2144	−11.2220	−11.2182	+208.3692	....	+ 7.6	+72.6	57.8
49 to 48	1.715	1445.152	− 4.2731	− 4.2734	− 4.2733	+204.0959	....	+ 0.3	+72.9	0.1
48 to 58	1.924	1447.076	− 7.8070	− 7.8029	− 7.8049	+196.2910	....	− 4.1	+68.8	16.8
58 to 59	0.888	1447.964	− 2.2270	− 2.2308	− 2.2289	+194.0621	....	+ 3.8	+72.6	14.4
59 to 60	2.702	1450.666	−17.7108	−17.7106	−17.7107	+176.3514	....	− 0.2	+72.4	0.0
60 to 57	3.449	1454.115	− 9.1924	− 9.1887	− 9.1906	+167.1608	....	− 3.7	+68.7	13.7
57 to 56	0.805	1454.920	+ 0.2505	+ 0.2502	+ 0.2504	+167.4112	....	+ 0.3	+69.0	0.1
56 to 55	1.512	1456.432	+ 1.5765	+ 1.5711	+ 1.5738	+168.9850	....	+ 5.4	+74.4	29.2
55 to 54	2.032	1458.464	− 9.8100	− 9.8124	− 9.8112	+159.1738	....	+ 2.4	+76.8	5.8
54 to 53	2.306	1460.770	− 5.8564	− 5.8521	− 5.8543	+153.3195	....	− 4.3	+72.5	18.5
53 to 43	1.623	1462.393	− 0.5716	− 0.5669	− 0.5692	+152.7503	....	− 4.7	+67.8	22.1
43 to 44	1.936	1464.329	− 1.8103	− 1.8068	− 1.8086	+150.9417	....	− 3.5	+64.3	12.2
44 to 45	1.652	1465.981	− 2.5557	− 2.5547	− 2.5552	+148.3865	....	− 1.0	+63.3	1.0
45 to 39	1.252	1467.233	− 1.0028	− 1.0061	− 1.0044	+147.3821	....	+ 3.3	+66.6	10.9
39 to 40	1.512	1468.745	− 0.6134	− 0.6226	− 0.6180	+146.7641	....	+ 9.2	+75.8	84.6
40 to 41	1.584	1470.329	− 0.9310	− 0.9383	− 0.9347	+145.8294	....	+ 7.3	+83.1	53.3
41 to 42	1.050	1471.379	+ 0.3445	+ 0.3518	+ 0.3482	+146.1776	....	− 7.3	+75.8	53.3
42 to 34	2.681	1474.060	+ 2.1296	+ 2.1321	+ 2.1308	+148.3084	....	− 2.5	+73.3	6.2
34 to Y	0.438	1474.498	+11.1637	+11.1625	+11.1631	+159.4715	43.5	+ 1.2	+74.5	1.4
34 to 35	2.462	1476.960	− 2.9209	− 2.9241	− 2.9225	+145.3859	....	+ 3.2	+76.5	10.4
35 to 36	1.634	1478.594	− 0.2067	− 0.2022	− 0.2044	+145.1815	....	− 4.5	+72.0	20.2
36 to 37	2.336	1480.930	− 0.4961	− 0.4914	− 0.4938	+144.6877	....	− 4.7	+67.3	22.1
37 to 38	1.391	1482.321	− 0.2105	− 0.2142	− 0.2124	+144.4753	....	+ 3.7	+71.0	13.7

Transcontinental line of Spirit-levels—Continued.

SECTION V.—FROM MITCHELL, IND., TO SAINT LOUIS, MO.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod E, first line.	Rod F, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ²
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	(*mm.*)²
38 to 46	2.088	1484.409	− 0.0640	− 0.0603	− 0.0621	+144.4132	....	− 3.7	+67.3	13.7
46 to 47	1.353	1485.762	+ 2.9001	+ 2.8981	+ 2.8991	+147.3123	....	+ 2.0	+69.3	4.0
47 to 33	1.794	1487.556	+ 8.6598	+ 8.6459	+ 8.6528	+155.9651	....	+13.9	+83.2	193.2
33 to 32	0.848	1488.404	+ 8.2677	+ 8.2733	+ 8.2705	+164.2356	....	− 5.6	+77.6	31.4
32 to 31	1.948	1490.352	− 3.7156	− 3.7201	− 3.7178	+160.5178	....	+ 4.5	+82.1	20.2
31 to 30	2.856	1493.208	− 4.9627	− 4.9584	− 4.9606	+155.5572	....	− 4.3	+77.8	18.5
30 to 22	2.710	1495.918	+ 4.5787	+ 4.5746	+ 4.5767	+160.1339	....	+ 4.1	+81.9	16.8
22 to 23	1.056	1496.974	− 8.0543	− 8.0538	+ 8.0541	+152.0798	....	− 0.5	+81.4	0.2
23 to 24	2.970	1499.944	+12.2140	+12.2137	+12.2139	+164.2937	....	+ 0.3	+81.7	0.1
24 to 25	2.674	1502.618	− 8.0267	− 8.0187	− 8.0227	+156.2710	....	− 8.0	+73.7	64.0
25 to 26	0.910	1503.528	+ 0.8670	+ 0.8714	+ 0.8692	+157.1402	....	− 4.4	+69.3	19.4
26 to 29	2.352	1505.880	− 2.1918	− 2.1986	− 2.1952	+154.9450	....	+ 6.8	+76.1	46.2
29 to 28	2.484	1508.364	+ 1.8463	+ 1.8381	+ 1.8422	+156.7872	....	+ 8.2	+84.3	67.2
28 to 27	2.036	1510.400	+ 0.1554	+ 0.1474	+ 0.1514	+156.9386	....	+ 8.0	+92.3	64.0
27 to 21	1.074	1511.474	− 7.3365	− 7.3341	− 7.3353	+149.6033	....	− 2.4	+89.9	5.8
21 to Z	0.706	1512.180	+ 5.9810	+ 5.9783	+ 5.9796	+155.5829	44.4	+ 2.7	+92.6	7.3
21 to 20	1.510	1512.984	− 4.3996	− 4.3942	− 4.3969	+145.2064	....	− 5.4	+84.5	29.2
20 to 19	2.444	1515.428	− 6.3593	− 6.3592	− 6.3592	+138.8472	....	− 0.1	+84.4	0.0
19 to 16	2.612	1518.040	− 3.0963	− 3.0962	− 3.0963	+135.7509	....	− 0.1	+84.3	0.0
16 to 17	0.788	1518.828	+ 1.4418	+ 1.4445	+ 1.4432	+137.1941	....	− 2.7	+81.6	7.3
17 to 18	2.160	1520.988	+11.1511	+11.1487	+11.1499	+148.3440	....	+ 2.4	+84.0	5.8
18 to 8	2.048	1523.036	+ 1.1512	+ 1.1505	+ 1.1508	+149.4948	....	+ 0.7	+84.7	0.5
8 to 9	1.224	1524.260	− 4.0379	− 4.0364	− 4.0371	+145.4577	....	− 1.5	+83.2	2.2
9 to 10	2.766	1527.026	− 6.9323	− 6.9276	− 6.9300	+138.5277	....	− 4.7	+78.5	22.1
10 to 11	1.338	1528.364	+ 3.1842	+ 3.1856	+ 3.1849	+141.7126	....	− 1.4	+77.1	2.0
11 to 12	1.884	1530.248	− 1.8216	− 1.8158	− 1.8187	+139.8939	....	− 5.8	+71.3	33.6
12 to 13	1.106	1531.354	+ 4.3563	+ 4.3523	+ 4.3543	+144.2482	....	+ 4.0	+75.3	16.0
13 to 14	0.970	1532.324	+ 9.8019	+ 9.8009	+ 9.8014	+154.0496	....	+ 1.0	+76.3	1.0
14 to 15	1.198	1533.522	+ 9.7299	+ 9.7334	+ 9.7317	+163.7813	....	− 3.5	+72.8	12.5
15 to 7	2.417	1535.939	− 3.6203	− 3.6148	− 3.6176	+160.1637	....	− 5.5	+67.3	30.2
7 to 6	1.537	1537.476	− 0.9891	− 0.9851	− 0.9871	+159.1766	....	− 4.0	+63.3	16.0
6 to 5	2.074	1539.550	−17.4715	−17.4725	−17.4720	+141.7046	....	+ 1.0	+64.3	1.0
5 to 1	2.564	1542.114	−12.4928	−12.4946	−12.4937	+129.2109	....	+ 1.8	+66.1	3.2
1 to I	1.232	1543.346	+ 2.2159	+ 2.2141	+ 2.2150	+131.4259	44.6	+ 1.8	+67.9	3.2
I to A_3	0.090	1543.436	+ 1.1951	+ 1.1951	+ 1.1951	+132.6210	44.6	0.0	+67.9	0.0
A_3 to 2	0.953	1544.389	− 2.2227	− 2.2245	− 2.2236	+130.3974	....	+ 1.8	+69.7	3.2
2 to 3	0.192	1544.581	− 0.4059	− 0.4051	− 0.4055	+129.9919	....	− 0.8	+68.9	0.6
3 to 62	2.826	1547.407	− 4.4135	− 4.4080	− 4.4107	+125.5812	....	+ 4.5	+73.4	20.2
62 to 61	4.440	1551.847	+ 1.1834	+ 1.1837	+ 1.1835	+126.7647	....	− 0.3	+73.1	0.1
61 to 64	5.740	1557.587	+ 3.6275	+ 3.6248	+ 3.6262	+130.3909	....	+ 2.7	+75.8	7.3
64 to 67	2.326	1559.913	+ 3.8706	+ 3.8724	+ 3.8715	+134.2624	....	− 1.8	+74.0	3.2
67 to 66	3.034	1562.947	− 0.5495	− 0.5421	− 0.5458	+133.7166	....	− 7.4	+66.6	54.8
66 to 65	2.533	1565.480	+ 1.9632	+ 1.9676	+ 1.9654	+135.6820	....	− 4.4	+62.2	19.4
65 to 82	1.984	1567.464	+ 7.9713	+ 7.9780	+ 7.9746	+143.6566	....	− 6.7	+55.5	44.9
82 to 83	1.781	1569.245	+ 9.5233	+ 9.5233	+ 9.5233	+153.1799	....	0.0	+55.5	0.0
83 to 84	1.984	1571.229	+ 4.7647	+ 4.7717	+ 4.7682	+157.9481	....	− 7.0	+48.5	49.0
84 to 89	1.636	1572.865	− 8.6453	− 8.6425	− 8.6439	+149.3042	....	− 2.8	+45.7	7.8
89 to 90	1.726	1574.591	− 9.4631	− 9.4598	− 9.4614	+139.8428	....	− 3.3	+42.4	10.9
90 to 91	2.580	1577.171	+11.1975	+11.2026	+11.2000	+151.0428	....	− 5.1	+37.3	26.0
91 to 92	2.169	1579.340	+ 5.9209	+ 5.9165	+ 5.9187	+156.9615	....	+ 4.4	+41.7	19.4
92 to 93	2.616	1581.956	+ 7.7484	+ 7.7441	+ 7.7463	+164.7078	....	+ 4.3	+46.0	18.5
93 to 68	2.461	1584.417	− 9.2658	− 9.2718	− 9.2688	+155.4390	....	+ 6.0	+52.0	36.0
68 to 69	2.658	1587.075	+ 4.0827	+ 4.0850	+ 4.0838	+159.5228	....	− 2.3	+49.7	5.3
69 to 70	2.045	1589.120	− 5.5777	− 5.5758	− 5.5767	+153.9461	....	− 1.9	+47.8	3.6
70 to 71	1.984	1591.104	+ 0.7068	+ 0.7039	+ 0.7053	+154.6514	....	+ 2.9	+50.7	8.4
71 to 72	2.346	1593.450	− 2.7253	− 2.7214	− 2.7233	+151.9281	....	− 3.9	+46.8	15.2
72 to 73	0.925	1594.375	− 6.2494	− 6.2539	− 6.2517	+145.6764	....	+ 4.5	+51.3	20.2

Transcontinental line of Spirit-levels—Continued.

SECTION V.—FROM MITCHELL, IND., TO SAINT LOUIS, MO.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod E, first line.	Rod F, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	±*mm.*	*mm.*	*mm.*	$(mm)^2$.
73 to II	0.346	1594.721	+ 1.0858	+ 1.0839	+ 1.0849	+146.7613	45.1	+ 1.9	+53.2	3.6
II to B_3	0.376	1595.097	+ 1.7392	+ 1.7412	+ 1.7402	+148.5015	45.1	− 2.0	+51.2	4.0
73 to 74	2.166	1596.541	−14.1528	−14.1514	−14.1521	+131.5243	....	− 1.4	+49.9	2.0
74 to 75	0.965	1597.506	+ 3.1006	+ 3.0997	+ 3.1002	+134.6245	....	+ 0.9	+50.8	0.8
75 to 81	3.000	1600.506	− 1.2031	− 1.2043	− 1.2037	+133.4208	....	+ 1.2	+52.0	1.4
81 to 79	1.306	1601.812	+ 6.0955	+ 6.0999	+ 6.0977	+139.5185	....	− 4.4	+47.6	19.4
79 to 78	1.690	1603.502	+ 0.9105	+ 0.9063	+ 0.9084	+140.4269	....	+ 4.2	+51.8	17.6
78 to 77	1.729	1605.231	+ 4.9426	+ 4.9365	+ 4.9395	+145.3664	....	+ 6.1	+57.9	37.2
77 to 76	1.779	1607.010	+ 0.2799	+ 0.2841	+ 0.2820	+145.6484	....	− 4.2	+53.7	17.6
76 to 80	1.627	1608.637	− 3.4410	− 3.4375	− 3.4392	+142.2092	....	− 3.5	+50.2	12.2
80 to 85	2.206	1610.843	−10.2226	−10.2154	−10.2190	+131.9902	....	− 7.2	+43.0	51.8
85 to 86	2.806	1613.651	− 2.0615	− 2.0665	− 2.0640	+129.9262	....	+ 5.0	+48.0	25.0
86 to 87	1.166	1614.817	+ 1.0662	+ 1.0647	+ 1.0655	+130.9917	....	+ 1.5	+49.5	2.2
87 to III	0.858	1615.675	+ 0.0422	+ 0.0422	+ 0.0422	+131.0339	45.3	0.0	+49.5	0.0
III to 94	1.932	1617.607	− 0.6800	− 0.6782	− 0.6791	+130.3548	....	− 1.8	+47.7	3.2
94 to 96	2.877	1620.484	+ 8.8059	+ 8.8074	+ 8.8066	+139.1614	....	− 1.5	+46.2	2.2
96 to 97	1.560	1622.044	+ 4.2585	+ 4.2631	+ 4.2608	+143.4222	....	− 4.6	+41.6	21.2
97 to 98	1.441	1623.485	− 2.7038	− 2.7094	− 2.7066	+140.7156	....	+ 5.6	+47.2	31.4
98 to 99	1.596	1625.081	− 0.2468	− 0.2447	− 0.2457	+140.4699	....	− 2.1	+45.1	4.4
99 to 100	1.228	1626.309	− 3.0926	− 3.0914	− 3.0920	+137.3779	....	− 1.2	+43.9	1.4
100 to 101	1.652	1627.961	+ 5.3683	+ 5.3742	+ 5.3712	+142.7491	....	− 5.9	+38.0	34.8
101 to 102	1.262	1629.223	+ 3.4517	+ 3.4474	+ 3.4495	+146.1986	....	+ 4.3	+42.3	18.5
102 to C_3	0.346	1629.569	+ 3.5094	+ 3.5083	+ 3.5089	+149.7075	45.5	+ 1.1	+43.4	1.2
C_3 to 103	1.804	1631.373	− 0.7167	− 0.7165	− 0.7166	+148.9909	....	− 0.2	+43.2	0.0
103 to 104	1.019	1632.392	+ 3.0946	+ 3.0947	+ 8.0946	+152.0855	....	− 0.1	+43.1	0.0
104 to 111	1.477	1633.869	+ 0.8545	+ 0.8552	+ 0.8549	+152.9404	....	− 0.7	+42.4	0.5
111 to 110	2.041	1635.910	− 5.4351	− 5.4388	− 5.4365	+147.5039	....	+ 3.7	+46.1	13.7
110 to 109	1.536	1637.446	+ 5.7440	+ 5.7409	+ 5.7425	+153.2464	....	+ 3.1	+49.2	9.6
109 to 108	0.676	1638.122	+ 0.5277	+ 0.5274	+ 0.5276	+153.7740	....	+ 0.3	+49.5	0.1
108 to 107	1.732	1639.854	+ 3.3891	+ 3.3885	+ 3.3888	+157.1628	....	+ 0.6	+50.1	0.4
107 to 106	1.974	1641.828	− 3.7905	− 3.7927	− 3.7916	+153.3712	....	+ 2.2	+52.3	4.8
106 to 105	2.392	1644.220	+13.6425	+13.6493	+13.6459	+167.0171	....	− 6.8	+45.5	46.2
105 to 121	1.460	1645.680	− 6.4476	− 6.4480	− 6.4478	+160.5693	....	+ 0.4	+45.9	0.2
121 to 120	2.366	1648.046	+ 5.2644	+ 5.2712	+ 5.2678	+165.8371	....	− 6.8	+39.1	46.2
120 to 119	1.996	1650.042	− 7.1607	− 7.1647	− 7.1627	+158.6744	....	+ 4.0	+43.1	16.0
119 to 118	1.640	1651.682	− 3.7410	− 3.7387	− 3.7399	+154.9345	....	− 2.3	+40.8	5.3
118 to IV	1.800	1653.482	−10.8356	−10.8323	−10.8339	+144.1006	45.7	− 3.3	+37.5	10.9
IV to 117	1.188	1654.670	+ 8.7609	+ 8.7596	+ 8.7602	+152.8608	....	+ 1.3	+38.8	1.7
117 to 116	2.010	1656.680	+ 2.8500	+ 2.8559	+ 2.8529	+155.7137	....	− 5.9	+32.9	34.8
116 to 115	0.938	1657.618	+ 2.5645	+ 2.5727	+ 2.5686	+158.2823	....	− 8.2	+24.7	67.2
115 to 114	1.334	1658.952	+ 1.3386	+ 1.3404	+ 1.3395	+159.6218	....	− 1.8	+22.9	3.2
114 to 113	2.022	1660.974	+ 6.2187	+ 6.2085	+ 6.2136	+165.8354	....	+10.2	+33.1	104.0
113 to 112	3.009	1663.983	− 5.4294	− 5.4288	− 5.4291	+160.4063	....	− 0.6	+32.5	0.4
112 to 122	1.990	1665.973	− 3.1088	− 3.1047	− 3.1067	+157.2996	....	− 4.1	+28.4	16.8
122 to 122½	1.901	1667.874	+ 1.0567	+ 1.0577	+ 1.0572	+158.3568	....	− 1.0	+27.4	1.0
122½ to 123	1.908	1669.782	+ 2.4204	+ 2.4222	+ 2.4213	+160.7781	....	− 1.8	+25.6	3.2
123 to 124	1.916	1671.698	+ 3.0214	+ 3.0171	+ 3.0192	+163.7973	....	+ 4.3	+29.9	18.5
124 to D_2	0.726	1672.424	+ 2.6139	+ 2.6126	+ 2.6133	+166.4106	46.0	+ 1.3	+31.2	1.7
124 to 128	1.326	1673.024	+ 1.7116	+ 1.7109	+ 1.7113	+165.5086	....	+ 0.7	+30.6	0.5
128 to 127	2.217	1675.241	− 0.0387	− 0.0382	− 0.0385	+165.4701	....	− 0.5	+30.1	0.2
127 to 126	1.785	1677.026	+ 1.0158	+ 1.0190	+ 1.0174	+166.4875	....	− 3.2	+26.9	10.2
126 to 125	2.026	1679.052	− 4.4221	− 4.4153	− 4.4187	+162.0688	....	− 6.8	+20.1	46.2
125 to V	1.778	1680.830	− 0.7193	− 0.7232	− 0.7212	+161.3476	46.0	+ 3.9	+24.0	15.2
V to 129	2.172	1683.002	− 1.4676	− 1.4739	− 1.4708	+159.8768	....	+ 6.3	+30.3	39.7
129 to 130	2.388	1685.390	− 2.7825	− 2.7850	− 2.7837	+157.0931	....	+ 2.5	+32.8	6.2
130 to 131	1.776	1687.166	− 1.3279	− 1.3338	− 1.3308	+155.7623	....	+ 5.9	+38.7	34.8

Transcontinental line of Spirit-levels—Continued.

SECTION V.—FROM MITCHELL, IND., TO SAINT LOUIS, MO.—Continued.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench mark.	Difference of height of successive bench-marks. Rod E, first line.	Rod F, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	$(mm.)^2$
131 to 134	2.192	1689.358	− 1.6774	− 1.6774	− 1.6774	+154.0849		0.0	+38.7	0.0
134 to VI	1.740	1691.098	− 4.6074	− 4.6038	− 4.6056	+149.4793	46.2	− 3.6	+35.1	13.0
VI to 133	0.528	1691.626	− 1.1486	− 1.1485	− 1.1486	+148.3307		− 0.1	+35.0	0.0
133 to 132	2.235	1693.861	− 5.6072	− 5.6115	− 5.6093	+142.7214		+ 4.3	+39.3	18.5
132 to 135	3.176	1697.037	+ 0.0099	+ 0.0116	+ 0.0107	+142.7321		− 1.7	+37.6	2.9
135 to 136	2.266	1699.303	− 4.7711	− 4.7757	− 4.7734	+137.9587		+ 4.6	+42.2	21.2
136 to VII	2.285	1701.588	− 1.2113	− 1.2152	− 1.2132	+136.7455	46.2	+ 3.9	+46.1	15.2
VII to 138	2.347	1703.935	+ 5.6171	+ 5.6199	+ 5.6185	+142.3640		− 2.8	+43.3	7.8
138 to 139	2.472	1706.407	+ 1.9595	+ 1.9626	+ 1.9610	+144.3250		− 3.1	+40.2	9.6
139 to E_3	1.540	1707.947	− 9.9514	− 9.9558	− 9.9536	+134.3714	46.3	+ 4.4	+44.6	19.4
E_3 to 137	0.936	1708.883	+ 4.0306	+ 4.0326	+ 4.0316	+138.4030		− 2.0	+42.6	4.0
137 to F_3	0.217	1709.100	+ 4.9910	+ 4.9902	+ 4.9906	+143.3936	46.3	+ 0.8	+43.4	0.6
137 to 147	2.412	1711.295	+ 3.9929	+ 3.9978	+ 3.9953	+142.3983		− 4.9	+38.5	24.0
147 to 146	2.278	1713.573	− 2.3521	− 2.3571	− 2.3546	+140.0437		+ 5.0	+43.5	25.0
146 to 145	1.946	1715.519	− 1.8960	− 1.8918	− 1.8939	+138.1498		− 4.2	+39.3	17.6
145 to 144	2.442	1717.961	− 3.0026	− 2.9973	− 2.9999	+135.1499		− 5.3	+34.0	28.1
144 to 143	1.931	1719.892	− 1.9395	− 1.9432	− 1.9414	+133.2085		+ 3.7	+37.7	13.7
143 to 142	0.606	1720.498	+ 0.7691	+ 0.7699	+ 0.7695	+133.9780		− 0.8	+36.9	0.6
142 to 141	1.892	1722.390	+ 4.0525	+ 4.0525	+ 4.0543	+138.0323		− 3.6	+33.3	13.0
141 to 140	0.554	1722.944	+ 0.6659	+ 0.6680	+ 0.6670	+138.6993		− 2.1	+31.2	4.4
140 to 148	2.324	1725.268	+ 4.2323	+ 4.2287	+ 4.2305	+142.9298		+ 3.6	+34.8	13.0
148 to 149	1.756	1727.024	− 2.3477	− 2.3465	− 2.3471	+140.5827		− 1.2	+33.6	1.4
149 to 150	2.037	1729.061	− 0.5254	− 0.5248	− 0.5251	+140.0576		− 0.6	+33.0	0.4
150 to 151	0.652	1729.713	+ 2.3568	− 2.3547	+ 2.3557	+142.4133		+ 2.1	+35.1	4.4
151 to VIII	2.406	1732.119	− 3.8148	− 3.8230	− 3.8189	+138.5944	46.6	+ 8.2	+43.3	67.2
VIII to 153	2.522	1734.641	+ 5.7657	+ 5.7723	+ 5.7690	+144.3634		− 6.6	+36.7	43.6
153 to 152	1.818	1736.459	+ 7.4267	+ 7.4269	+ 7.4268	+151.7902		− 0.2	+36.5	0.0
152 to 154	2.134	1738.593	+ 6.5333	+ 6.5368	+ 6.5351	+158.3253		− 3.5	+33.0	12.2
154 to 155	2.173	1740.766	+ 7.6667	− 7.6614	− 7.6641	+150.6612		− 5.3	+27.7	28.1
155 to 156	2.038	1742.804	− 4.1831	− 4.1793	− 4.1812	+146.4800		− 3.8	+23.9	14.4
156 to G.A.F	0.194	1742.998	+ 1.9902	+ 1.9894	+ 1.9898	+148.4698	46.7	+ 0.8	+24.7	0.6
156 to 157	1.641	1744.445	+ 0.1797	+ 0.1751	+ 0.1774	+146.6574		+ 4.6	+28.5	21.2
157 to 158	2.136	1746.581	−12.1447	−12.1421	−12.1434	+134.5140		− 2.6	+25.9	6.8
158 to 159	0.906	1747.487	+ 0.9496	+ 0.9525	+ 0.9511	+135.4651		− 2.9	+23.0	8.4
159 to G_3	0.818	1748.305	+ 4.6316	+ 4.6344	+ 4.6330	+140.0981	46.7	− 2.8	+20.2	7.8
159 to 166	2.597	1750.084	− 2.3251	− 2.3306	− 2.3279	+133.1372		+ 5.5	+28.5	30.2
166 to 165	2.060	1752.144	+10.9278	+10.9236	+10.9257	+144.0629		+ 4.2	+32.7	17.6
165 to 164	2.022	1754.166	+15.4386	+15.4455	+15.4421	+159.5050		− 6.9	+25.8	47.6
164 to 163	2.712	1756.878	+ 8.8780	+ 8.8775	+ 8.8777	+168.3827		+ 0.5	+26.3	0.2
163 to 162	1.077	1757.955	− 1.5163	− 1.5160	− 1.5161	+166.8666		− 0.3	+26.0	0.1
162 to 161	1.777	1759.732	+ 2.0339	+ 2.0298	+ 2.0318	+168.8984		+ 4.1	+30.1	16.8
161 to 160	2.288	1762.020	+ 3.4454	+ 3.4400	+ 3.4427	+172.3411		+ 5.4	+35.5	29.2
160 to 167	2.153	1764.173	− 5.3718	− 5.3712	− 5.3715	+166.9696		− 0.6	+34.9	0.4
167 to 168	1.577	1765.750	−12.1110	−12.1113	−12.1111	+154.8585		+ 0.3	+35.2	0.1
168 to 169	1.922	1767.672	−11.5356	−11.5273	−11.5315	+143.3270		− 8.3	+26.9	68.9
169 to IX	1.430	1769.102	− 5.5280	− 5.5336	− 5.5308	+137.7962	47.0	+ 5.6	+32.5	31.4
IX to 170	0.497	1769.599	− 2.8123	− 2.8126	− 2.8124	+134.9838		+ 0.3	+32.8	0.1
170 to 172	0.606	1770.205	− 3.0494	− 3.0471	− 3.0483	+131.9355		− 2.3	+30.5	5.3
172 to 171	1.944	1772.149	− 2.0654	− 2.0632	− 2.0643	+129.8712		− 2.2	+28.3	4.8
171 to H_3	1.005	1773.154	+29.8292	+29.8278	+29.8285	+159.6997	47.1	+ 1.4	+29.7	2.0
170 to 178	1.116	1770.715	− 5.1441	− 5.1408	− 5.1425	+129.8413		− 3.3	+29.5	10.9
178 to 177	2.514	1773.229	− 0.7519	− 0.7585	− 0.7552	+129.0861		+ 6.6	+36.1	43.6
177 to 176	2.106	1775.335	− 0.0106	− 0.0073	− 0.0089	+129.0772		− 3.3	+32.8	10.9
176 to 175	1.854	1777.189	− 0.3143	− 0.3094	− 0.3119	+128.7653		− 4.9	+27.9	24.0
175 to 174	2.846	1780.035	+ 0.9271	+ 0.9238	+ 0.9255	+129.6908		+ 3.3	+31.2	10.9
174 to 173	2.118	1782.153	− 2.3301	− 2.3265	− 2.3233	+127.3675		+ 6.4	+37.6	41.0

Transcontinental line of Spirit-levels—Continued.

SECTION IV.—FROM MITCHELL, IND., TO SAINT LOUIS, MO.—Concluded.

Bench-marks.	Distance between bench-marks.	Total distance Sandy Hook to bench-mark.	Difference of height of successive bench-marks. Rod E, first line.	Rod F, second line.	Mean.	Total height above mean sea-level at Sandy Hook.	Probable error of total height.	Discrepancy. Partial Δ	Total.	Δ^2
	km.	*km.*	*m.*	*m.*	*m.*	*m.*	± *mm.*	*mm.*	*mm.*	(*mm.*)²
173 to 179	1.202	1783.355	− 1.2296	− 1.2340	− 1.2318	+126.1357	....	+ 4.4	+42.0	19.4
179 to I_3	0.059	1783.414	+ 0.7713	+ 0.7706	+ 0.7709	+126.9066	47.2	+ 0.7	+42.7	0.5
179 to 183	0.025	1783.380	+22.4494	+22.4489	+22.4491	+148.5848	....	+ 0.5	+42.5	0.2
183 to 182	0.624	1784.004	− 0.7478	− 0.7442	− 0.7460	+147.8388	....	− 3.6	+38.9	13.0
182 to 184	0.000	1784.004	−19.8287	−19.8287	−19.8287	+128.0101	....	0.0	+38.9	0.0
184 to 180	0.020	1784.024	− 1.2238	− 1.2233	− 1.2235	+126.7866	....	− 0.5	+38.4	0.2
179 to 185	0.052	1783.407	− 0.7328	− 0.7329	− 0.7329	+125.4028	....	+ 0.1	+42.1	0.0
185 to E.T.G	0.374	1783.781	− 5.7827	− 5.7801	− 5.7814	+119.6214	....	− 2.6	+39.5	6.8
185 to 186	0.590	1783.997	....	....	− 0.1599	+125.2429	....	....	+42.1	....
186 to W.T.G	0.116	1784.113	− 5.6164	− 5.6160	− 5.6162	+119.6267	....	− 0.4	+41.7	0.2
186 to 180	0.058	1784.055	+ 1.5394	+ 1.5388	+ 1.5391	+126.7820	....	+ 0.6	+42.7	0.4
180	....	1784.040	....	....	....	+126.7843	....	....	40.6	....
180 to J_3	0.067	1784.107	+ 0.1234	+ 0.1234	+ 0.1234	+126.9077	47.2	0.0	+40.6	0.0
180 to K_3	0.636	1784.676	+ 0.1230	+ 0.1239	+ 0.1235	+126.9078	47.2	− 0.9	39.7	0.8

SECTION V.—*Description of primary and secondary bench-marks between Mitchell, Ind., and Saint Louis, Mo.*

X—Mitchell, Ind.; already described.

Y—The centre of a cross, cut on the face of the stone cap of a basement window, on the northwest side of the court-house at West Shoals, Martin County, Indiana. It is marked thus:

Y
B + M

Z—Cut on the sill of a basement window, at southeast corner of court-house at Washington, Daviess County, Indiana. It is marked thus:

Z
B □ M
U. S. C. & G. S.
1882.

A_3—Cut on the stone ledge on the northwest front of the court-house at Vincennes, Ind. It is marked thus:

A_3
B □ M
U. S. C. & G. S.
1882.

No. I—The centre of the top surface of the easternmost stone pier of the Coast and Geodetic Survey astronomical observatory, in the grounds of the Vincennes court-house.

B_3—Cut at the base of one of the columns of the north face of the court-house at Olney, Richland County, Illinois. It is marked thus:

B_3
B □ M
U. S. C. & G. S.
1882.

No. II—Near the southeast corner of the grounds of the public school at Olney, Ill., on the monument marking the end of the U. S. E. base-line.

The top of the monument bears the inscription "U. S.," and the bench-mark is the centre of the space inclosed by the lower curve of the S.

No. III—Cut on the eastern abutment of Ohio and Mississippi Railroad bridge over Little Wabash River, about 1½ miles east of Clay City, Ill., and is marked thus: B □ M.

C_3—Cut on a front basement window, near southeast corner of the public school building at Flora, Clay County, Illinois, and is marked thus:

C_3
B □ M
U. S. C. & G. S.
1882.

No. IV—Cut on the west abutment of Ohio and Mississippi Railroad trestle over Skillet Fork of Little Wabash River, about 2½ miles east of Iuka, Ill. It is marked thus:

B □ M
IV

D_3—The centre of a cross, cut on the southwest corner of the court-house at Salem, Ill. It is marked thus:

D_3
B □ M
U. S. C. & G. S.
1882.

No. V—Cut on the coping stone, at the east end of a long arched culvert, at Odin Station of Ohio and Mississippi Railroad. It is marked thus:

B. M. V.
□

No. VI—Cut on the west abutment of Ohio and Mississippi Railroad trestle about 2½ miles west of Sandoval, Ill. It is marked thus:

U. S.
B □ M
VI.

No. VII—Cut on the west abutment of Ohio and Mississippi Railroad culvert about one-fourth mile east of Collins Station, and is marked thus:

B □ M.
VII

E_3—About one-fourth mile east of Carlyle, Ill. Cut on a pier of the Ohio and Mississippi Railroad bridge over the Kaskaskia River. It is marked thus:

E_3
B □ M
U. S. C. & G. S.
1882.

F_3—Cut on the station ledge, under the windows of the east face of the court-house at Carlyle, Ill. It is marked thus:

B □ M
F_3
U. S. C. & G. S.
1882.

No. VIII—Cut on west abutment of Ohio and Mississippi Railroad bridge over Sugar Creek, about 1 mile west of Ariston, Ill. It is marked thus:

U. S.
B □ M
VIII.

G_3—Cut on the sill of a basement window on the east face of the public school building at Lebanon, Saint Clair County, Illinois. It is marked thus:

1882
U. S. C. & G. S.
G_3
B ☐ M.

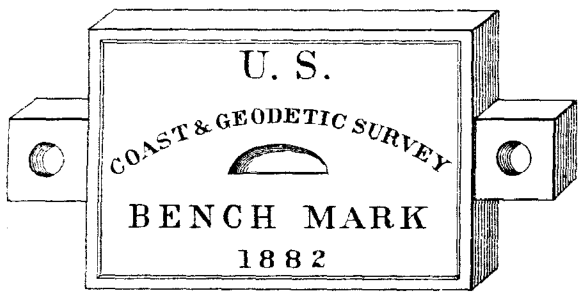
No. IX—Cut on the east abutment of Ohio and Mississippi Railroad bridge, about one-fourth mile east of Caseyville, Saint Clair County, Illinois. It is marked thus:

B ☐ M
IX.

H_3—The centre of the head of the copper bolt inserted in the stone monument marking the north end of the "American Bottom Base."

I_3—A mark on a large bronze plate inserted in the south face of the eastern land pier of the "Great Bridge" at East Saint Louis, Ill.

The plate bears the inscription—



J_3—A similar plate inserted in the western land pier of the "Great Bridge" at Saint Louis. Bench-marks I_3 and J_3 were placed as near as possible on the same level as the Saint Louis (so-called) "City Directrix" described below.

K_3—Known at Saint Louis as the "City Directrix." It has been in use for many years, and was originally the top surface of the pedestal of a monument which stood on Front street near Market. The monument shaft was destroyed at the time of the great fire in that locality, but the pedestal remained. It is now level with the curbstone and forms a part thereof. A ┬ mark has since been cut to indicate the point used for a bench-mark.

U.S. COAST AND GEODETIC SURVEY

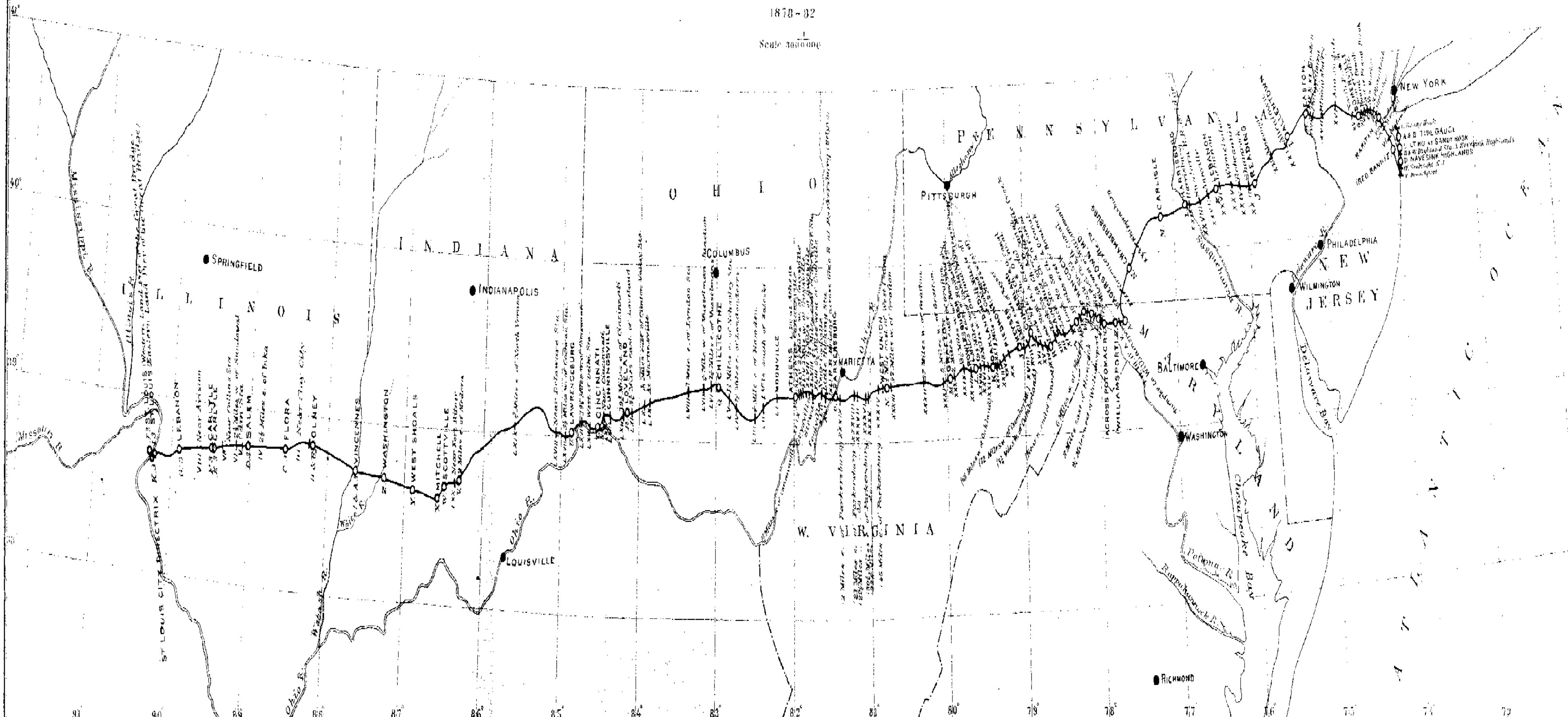
J.E. Hilgard, Supt.

TRANSCONTINENTAL LINE OF SPIRIT-LEVELS

SKETCH SHOWING THE POSITION OF THE PRINCIPAL BENCH-MARKS

SANDY HOOK, N.J. TO ST. LOUIS, MO.

1878–82



APPENDIX No. 23.

EXPERIMENTAL RESEARCHES ON THE FORCE OF GRAVITY.

By CHARLES S. PEIRCE, Assistant.

Owing to the already bulky proportions of this volume, Appendix No. 23 has been transferred to, and will appear in, the Annual Report of the Superintendent for the year 1883.

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APPENDIX No. 24.

TRIBUTE TO THE MEMORY OF CARLILE P. PATTERSON, SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY FROM 1874 TO 1881.

CARLILE P. PATTERSON.

IN MEMORIAM.

OFFICIAL ANNOUNCEMENT OF THE DEATH OF THE SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY.

The Department mourns, in the sudden death of Carlile P. Patterson, Superintendent of the United States Coast and Geodetic Survey, the loss of one of its most eminent and valuable officers. Mr. Patterson's death took place at his residence, near Washington, on Monday, the 15th of August. His efforts have been so earnest in the performance of the various duties which have devolved upon him, that to his untiring prosecution of them the immediate loss of his life is to be attributed. With unbounded zeal and ceaseless energy, he pressed on without taking the relaxation which nature demanded.

Carlile P. Patterson was born at Shieldsboro, Bay of Saint Louis, Miss., August 24, 1816. He was appointed a midshipman in the United States Navy in 1830; served in the Mediterranean Squadron, and in 1836 returned home, and graduated from Georgetown College, Kentucky, in 1838. Having served as passed midshipman on the Coast Survey until 1841, he was again on naval sea service until 1844, and subsequently, as lieutenant, United States Navy, had charge of a hydrographic party on the Coast Survey for four years. In 1850 he took command of a Pacific mail steamship, and continued in that and other private business until 1861. He then returned to the Coast Survey as Inspector of Hydrography, and so remained until he was appointed Superintendent of that work in February, 1874.

Combining wide experience with great judgment, he was eminently successful in the conduct of the great national work under his charge, and in his hands its scope was greatly enlarged, and its character as a general geodetic survey became fully recognized. That the interests of science, which had been so carefully fostered by his predecessor, so far as compatible with the objects of the work, were not neglected by Mr. Patterson, is attested by the fact that he received the honorary degree of LL.D., and was elected to membership in several leading scientific societies. Of the Light-House Board he was an honored and useful member, bringing into its discussions not only ripe experience, but particular and intimate knowledge of the points to be decided.

Mr. Patterson was chairman of a commission appointed by Secretary Boutwell, in 1869, to examine into the condition of the Revenue Cutter Service, the report of which commission, made after some two years of patient investigation, was adopted, and resulted in a large saving of expense, and in a fourfold increase of efficiency. He was also a member of the commission, created in 1872, to examine and test life-saving apparatus. The report made by this commission was carried into effect with excellent results to the Life-Saving Service.

The personal character of the late Superintendent was such as to attract friendship and command esteem. Frank and truthful, full of generous impulse, ardent in the cause he represented, strict in the administration of his trusts, he secured the entire confidence of this Department and of the representatives of the Nation in Congress.

As a tribute to his memory, the office of the Coast and Geodetic Survey will be draped in black, and will be closed on the day of the funeral.

WILLIAM WINDOM,
Secretary.

TREASURY DEPARTMENT, *August* 17, 1881.

ACTION OF THE OFFICERS OF THE TREASURY DEPARTMENT.

At a meeting of the officers of the Treasury Department, held in the office of the Secretary, August 16, 1881, the following preamble and resolutions were adopted:

Whereas it has pleased an all-wise Providence to remove from our midst by death Carlile P. Patterson, Superintendent of the Coast and Geodetic Survey of the United States, and a member of the Light-House Board: Therefore,

Resolved, That in the death of Superintendent Patterson the whole country has sustained the loss of an honest, able, efficient, and valuable officer, who combined great judgment with large experience, firmness with courtesy; ardent in the performance of duty, wise in council, strict and faithful in the administration of his trusts. Devoted as he was to the advancement of the public interests, he ever sought to perfect the work of which he had charge.

Resolved, That, as a citizen, in all the relations of life, he justly shared the confidence and esteem of all who knew him.

Resolved, That the condolence and sympathy of this meeting are hereby tendered to the bereaved wife and family of the deceased.

WILLIAM WINDOM,
Chairman.
JOHN RODGERS,
WILLIAM LAWRENCE,
J. E. HILGARD,
Committee.

ACTION TAKEN AT THE OFFICE OF THE COAST AND GEODETIC SURVEY.

At a meeting of the Assistants and other persons employed in the Coast and Geodetic Survey, held at the Office of the Survey, on the 17th of August, upon the occasion of the death of the Superintendent of the Survey, remarks were made by Assistants Hilgard, Cutts, Boutelle, Mitchell, Whiting, and Goodfellow, by Commander C. M. Chester, United States Navy, Hydrographic Inspector, and by Samuel Hein, esq.

The following preamble and resolutions were then unanimously adopted:

"The officers and members of the Coast and Geodetic Survey, assembled here to-day, desire to express their sense of the loss the work has met with in the death of Carlile Pollock Patterson, its Superintendent for the past seven years.

"Mr. Patterson's appointment to the work as Superintendent was in recognition of his eminent ability and efficiency as Hydrographic Inspector, his deep and almost life-long interest in all that pertained to the service, his readiness and fertility of resource both in council and in action, and his constant effort to uphold a high standard of honorable ambition among his associates.

"These qualities were at once manifested when he assumed the great responsibilities of his position as the successor of Benjamin Peirce in the superintendency. It was a time of general commercial depression, when all appropriations were cut down close to, and often below, the point of efficiency. This was the case with the appropriations for the Coast and Geodetic Survey, and the full powers of the new Superintendent were put forth to keep unbroken the organization of the work, knowing well that once seriously impaired it could with difficulty be restored.

"This struggle the late Superintendent successfully maintained, despite every obstacle, to the close of his administration, and his death took place at a time when a brighter prospect appeared in view.

"To put upon record their sense of his public services, the officers and members of the Survey have adopted the following resolutions:

"I. That in the death of Mr. C. P. Patterson, Superintendent of the Coast and Geodetic Survey, they deplore the loss of an upright man, an able and energetic officer, and a sincere friend.

"II. That they extend to the family of the late Superintendent their profound sympathy in the great calamity that has overtaken them."

Mr. HILGARD said:

We meet to give expression to our deep sense of the great loss which we ourselves have sustained, no less than the public service, by the sudden death of our late chief, Carlile P. Patterson, Superintendent of the Coast and Geodetic Survey. There are few among us who can feel more deeply than myself this unexpected severance of official and personal relations. My association with Mr. Patterson on this Survey began thirty-five years ago, when I sailed with him from New York to Mobile in a small schooner of which he was lieutenant commanding—both about to commence work in the Gulf of Mexico. That voyage and subsequent co-operation in the work of the Coast Survey established intimate relations of personal friendship, which were suspended only by wide divergence in the field of our operations.

In the days of peace, when no opportunity of distinction appeared open to a lieutenant in the Navy, the ardent enterprise of Patterson led him to cast his lot, during the great material development of our country consequent upon the addition of California to the national domain, as a commander of steamships carrying that great tide of emigration; and subsequently, while serving on the North Pacific line, in extending the new civilization to the shores of Columbia River and Puget Sound. After taking a prominent part in the great movement of our population to the Golden State, he was recalled to his home by family ties, and, on the outbreak of the civil war, found a worthy field for his varied professional acquirements in the direction of the hydrographic work of the Coast Survey under our former lamented chief, Professor Bache. Those who knew Patterson well cannot doubt that, had he remained in the service, opportunities for distinction then offered would have found him at the close of the war among the foremost officers of the Navy.

Of Mr. Patterson's services to the Coast Survey, the occasion permits only the briefest recital—his biographer must do him the full justice which his great merits demand. While acting as Chief of Hydrography he entirely remodeled that service by adapting the character of the vessels and the organization of parties to their special ends, thereby largely reducing expenditure. Called to the superintendency on the retirement of Professor Peirce in 1874, he was met by the very difficult situation of having to maintain an organization which had gradually grown up out of the requirements of the country against a great contraction of public expenditures. This condition of affairs has, however, happily proved to be only temporary. His success in maintaining the scale of the Coast Survey under these adverse circumstances, and in expanding the scope of the work according to the policy laid down by his predecessor, so as to embrace a general geodetic survey of the country, will ever mark his administrative ability.

During the past eighteen years I have been in almost daily association with our late chief, either as co-adviser with him of the Superintendent, or during the past seven years, since he himself held that office, as his immediate executive officer. His death, by none dreamed of as so near at hand, is a great shock to me, and in my estimation, is a loss to the Coast Survey and public service, which can be realized only upon a review of the influence which he has exercised on all public matters with which he was connected. But his death is too recent—my emotion too deep—to permit me to say more in appreciation of his career. His personal character always excited my admiration. Full of ardor and generous impulses, frank and truthful, rigorous in the performance of duty, strict in the administration of his trusts, wise in council, combining good judgment with wide experience, he was, truly, a great man.

Mr. CUTTS said:

Thirty hours ago, while on duty at the far north, I received, at the same time, a letter and a telegram—the one informing me of a proposed visit on the part of the Superintendent, and the other announcing his death. No previous warning of danger had reached the field-officers of the Survey. Hastening on, with others who received the sad news in time, we have now each to express our personal and profound grief at the loss we have sustained.

His previous experience in the working of the Survey, especially of one of its most important branches; his ability as an executive officer, and his sound judgment in all matters pertaining to the interest and progress of the great work under his charge, have been tested and proved by seven years of successful administration. Those, however, more intimately connected with his official life, can tell of the never-ending interest and oversight which he gave to every detail, and with an intensity which, no doubt, laid the foundation of the malady of which he so suddenly died. He was a faithful friend, a man of the kindest and most generous impulses, great decision of character, and full of energy and life. As such I have known him from early manhood, under trying circumstances in the early days of California, and as Superintendent of the Survey. I deeply deplore his death.

Remarks of Mr. BOUTELLE:

To all that has been said here, and to all that is stated in the resolutions offered, I most heartily subscribe. In addition, I desire to say a word on the personal qualities of the friend so suddenly taken from us. I say friend in the full meaning of the term. During my service of nearly forty years in the Coast and Geodetic Survey, we have had three most eminent, noble, and generous men to preside over its destinies. In every noble quality, in his knightly scorn of subterfuge and meanness, open or implied, in his kindly appreciation of every good thought or action, Mr. Patterson was the full peer of his great predecessors, Bache and Peirce. For his devotion to the best interests of the great work we all have at heart, we owe him a debt of gratitude, and we cherish his memory as we lament his loss.

Mr. MITCHELL said:

Seventeen years ago, when Professor Bache was suddenly seized with the disease which caused his death, he cried, in his anguish of mind, "Send for Captain Patterson, that I may lean upon a strong man!" This call echoed along our ranks most heartily, and we all felt that the man who could be depended upon to support our great chief's failing footsteps was Mr. Patterson. And when, ten years later, our much-loved Peirce, wearied of the burden that had crushed his predecessor, proposed to throw up his commission, President Grant sent for that same strong man that Bache had designated.

The retirement of Professor Peirce was a serious disappointment to us all, for he had filled us with the enthusiasm of his own genius and widened all our paths. But we soon discovered that under the changed conditions consequent upon the undiscriminating spirit of retrenchment that appeared in Congress, we were entering upon a troubled sea, where the peculiar strength of our new chief was required at the helm.

Mr. Patterson was strong in intellectual resource, and strong in will; but, most of all, *he was strong in honesty.* He believed that we should live and work in the light of day, and he felt confident that Congress would support the Coast and Geodetic Survey, if it could see entirely through all its aims and all its purposes, and recognize that these were all genuine and practically useful.

He was strong in honesty, and that strength had its base in religious faith. He believed in God, and, therefore, in the ultimate triumph of good effort. More than this, he loved his God, and was ready to abide His will. In any doubtful case, he used to say, "We must use no specious argument; *we must never fight for victory.*"

To say that he was pure in life and pure in speech, repelling indelicacy by his own attitude, and prompting good thought and good action by instinctive sympathy, is only to repeat that *he was strong in honesty.*

But he, too, has been crushed at the wheel, and some of us, who knew him best and loved him most, are full of remorse to-day, remembering that even we, thoughtlessly, suffered him to carry our burdens.

Mr. PEIRCE said:

It is difficult to add to the words which have already been spoken, or to characterize more justly the administration of the chief whom we are all so suddenly called to mourn. One thing I feel most keenly: It is that American science loses a great support and friend.

Perhaps this is hardly known to those who were not near him. His superintendency was marked by such great practical achievements as the production of the Coast Pilot, and by improvements in innumerable details of the organization and running of the Survey. Yet, although he was not professedly a scientific man, under none of the eminent geodesists who had preceded him, was more stress laid upon the scientific branches of the work—to their extension, and to the precision of their execution. No one was so earnest as he to secure to the Survey the labors of men of purely scientific, and especially mathematical, attainments and abilities.

It was not very long ago that, in speaking to me of a mathematical discovery by a young man whom he had appointed to a position on the Survey, he expressed his conviction of the importance of having such minds ready at hand in the Survey to solve any problem which might arise. He had often said that; but on this occasion he added, that nothing about the office which he held gave him such real gratification as the opportunity it afforded him to aid in the development of that kind of genius. For such reasons I feel that in Patterson's death the science of the country has lost a staunch ally.

I will not trouble you with my personal affliction at the loss of him—"*O et præsidium et dulce decus meum.*" Never can I hope to find again so true a friend and so just a chief!

Mr. GOODFELLOW said:

Those of us now present who knew Mr. Patterson as Hydrographic Inspector of the Coast Survey, and then as its Superintendent, can bear full witness to his zeal for the work, to his unflagging energy, and to his persistent and untiring efforts for its advancement.

Trained early in the habit of command, a strict disciplinarian according to naval methods, an advocate rather of the "*fortiter in re*" than of the "*suaviter in modo*" in his ideas of government, he strove to impress his strong personality upon every branch of the service; and wherever he saw his way clearly he hesitated not to take the responsibility of action.

The successive steps of his career are known to nearly all of us, and we all know the high and exacting standard of personal service and devotion to duty which he upheld, and to which he himself became at last a martyr.

He did not live, as doubtless he would have desired to live, to see that day, now, as we trust, not far distant in the progress of the Survey, when the gradual extension of its work over the whole of the territory of the United States, and its steady advance to completion, shall be fostered by a hearty executive support, and sustained by a wise and liberal legislative policy. But he died, as perhaps he might have wished to die, by a swift and sudden stroke, in the very midst of his labors.

Lieutenant-Commander C. M. CHESTER, U. S. N., and Hydrographic Inspector Coast and Geodetic Survey, said:

Professor Hilgard has spoken of our lamented chief in his connection with the Coast and Geodetic Survey. I, as a representative of a large number of the service who are necessarily absent, desire to express their full sympathy with the members of this meeting in their sorrow at this great loss.

While only temporarily attached to the Survey, yet we of the Navy, being impressed with Mr. Patterson's uniform kindness, consideration, and great assistance rendered us, feel his loss in his double capacity of Superintendent and brother officer. Originally belonging to us, always connected with us by ties of love and friendship, he has ever taken the deepest interest in our welfare, and, as I have long maintained, done more for our naval service than almost any man in it. We have lost a friend indeed.

LIST OF SKETCHES.

ILLUSTRATIONS.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

Please Note:

This project currently includes the imaging of the full text of each volume up to the "List of Sketches" (maps) at the end. Future online links, by the National Ocean Service, located on the Historical Map and Chart Project webpage (http://historicals.ncd.noaa.gov/historicals/histmap.asp) will includes these images.

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